PROTA

Vegetables

Plant Resources of Tropical Africa 2

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Introduction

Choice of species

This PROTA 2: Vegetables book describes the cultivated and wild vegetable species of tropical Africa. Some of these are only used as a vegetable, but others have two or more uses. PROTA assigns one primary use and if relevant, one or more secondary uses to all plant species used in Africa. PROTA 2: Vegetables comprises only accounts of species whose primary use is as a vegetable. The primary use of baobab (*Adansonia digitata* L.) is as a leafy vegetable, and thus it is treated in PROTA 2, but it has several secondary uses, e.g. the fruit is eaten, oil is extracted from the seed, the wood is used for timber and fuel, the bark for fibre, and the bark and fruit for the preparation of medicines. Also cassava (*Manihot esculenta* Crantz) is quite important as a leafy vegetable, but its primary use is undoubtedly its edible starchy root, and consequently cassava is described in PROTA 8: Carbohydrates.
Species that are used as a vegetable but also have another primary use are listed after the primary use vegetables, and are fully described in other commodity groups. Some important species included in this list are: *Ipomoea batatas* (L.) Lam., *Manihot esculenta* Crantz, *Parkia biglobosa* (Jacq.) R.Br. ex G.Don, *Solanum tuberosum* L. and *Xanthosoma sagittifolium* (L.) Schott.
The definition of a vegetable as 'succulent plant parts consumed as side dish with a starchy staple food' is simple and clear at first sight. However, it is difficult to unambiguously delineate the commodity group vegetables, and the boundary with other commodity groups is sometimes arbitrary, e.g. that with commodity group spices and condiments. Capsicum pepper (*Capsicum annuum* L.) is used in fairly large quantities as a vegetable or in small quantities as a spice, depending on the capsaicin content of the fruits. Garlic is another example of a multipurpose plant, sometimes considered primarily a spice or medicinal plant, but treated in the commodity group vegetables.
A few leguminous species grown for their dry seeds can be important vegetables as well, i.e. for the consumption of immature seeds, green pods and/or leaves. Pea (*Pisum sativum* L.) and cowpea (*Vigna unguiculata* (L.) Walp.) are included in PROTA 2: Vegetables, but also in PROTA 1: Cereals and pulses. A special group are some *Cucurbitaceae*, e.g. melon and watermelon, the fruits of which are eaten raw. Because of their annual growth habit and cultivation as field crops these are conventionally included in PROTA 2: Vegetables and not in PROTA 6: Fruits. In addition, several *Cucurbitaceae* species grown for their dry seed, eaten as side dish or snack are treated as vegetables.
In PROTA 2: Vegetables comprehensive descriptions are given of about 110 important vegetable species. These major vegetables comprise most cultivated species, but also several wild or partly domesticated species. The accounts are presented in a detailed format and illustrated with a line drawing and a distribution map. In addition, accounts of some 170 vegetables of minor importance are given. Because information on these species is often scanty, these accounts are in a simplified format and do not include a drawing or map.

Plant names

Family: Apart from the classic family name, the family name in accordance with the Angiosperm Phylogeny Group (APG) classification is also given where it differs from the classic name.
Synonyms: Only the most commonly used synonyms and those that may cause confusion are mentioned.
Vernacular names: Only names in official languages of regional importance in Africa are included, English, French, Portuguese and Swahili. It is beyond the scope of PROTA to give an extensive account of the names of a species in all languages spoken in its area of distribution. Checking names would require extensive fieldwork by specialists. Although regional forms of Arabic are spoken in several countries in Africa, the number of African plant species that have a name in written, classical Arabic is limited. Arabic names are therefore omitted. Names of plant products are mentioned under the heading 'Uses'.

Origin and geographic distribution

To avoid long lists of countries in the text, a distribution map is added for major species. The map indicates in which countries a species has been recorded, either wild or planted. It should be realized that for many species these maps are incomplete because they are prepared on the basis of published information, the quantity and quality of which varies greatly from species to species. This is especially the case for wild species which are not or incompletely covered by the regional African floras, and for cultivated species which are only planted on a small scale (e.g. in home gardens). For some countries (e.g. Central African Republic, Chad, Sudan, Angola) there is comparatively little information in the literature. Sometimes they are not covered by recent regional or national floras and although species may be present there, this cannot be demonstrated or confirmed. For some major species, a distribution map has been omitted because there is too little information on distribution.
The assortment of market vegetables in African countries varies largely. In urban areas the 25 most important cultivated vegetables account for up to 90% of the total consumption of 100–150 g/person, whereas vegetables collected from the wild account for less than 5%. In rural areas the variation is greater and more wild vegetables are consumed. Large differences exist not only between urban and rural areas, but also between forest and savanna zones, lowland and highland regions, countries and tribes, and more generally between West, Central, East and Southern Africa and between Anglophone, Francophone and Portuguese-speaking countries. As an illustration of this location-dependent variation a list of the most important market vegetables is presented in Table 1. It shows differences between the West African forest zone (Lagos) and the savanna or Sahel area (Kano), between West Africa (Nigeria) and East Africa (Kenya) and between lowland (Mombasa) and highland (Nairobi). Many temperate-type vegetables are traded in West Africa from the savanna zone to the forest zone, and in East Africa from highland to lowland regions.

Table 1. Availability and relative importance of vegetables in urban markets in Nigeria (West Africa) and Kenya (East Africa)

Scientific name	common name	Nigeria		Kenya	
		Lagos	Kano	Nairobi	Mombasa
Abelmoschus caillei	West African okra	+++++	++++	0	0
Abelmoschus esculentus	okra	+++++	+++++	+++	+++++
Adansonia digitata	baobab	++ *	+++++	0	++
Allium cepa	bulb onion, shallot	+++++ *	+++++	+++++	+++++ **
Allium fistulosum	welsh onion	+++	++++	++	+ **
Allium sativum	garlic	+++ *	+++++	++++	+++ **
Amaranthus cruentus	amaranth	+++++	+++++	+++++	+++
Amaranthus dubius	amaranth	++++	++	+	++++
Basella alba	Ceylon spinach	++++	++	+	++
Brassica oleracea	headed cabbage	+++ *	+++++	+++++	+++++ **
Brassica oleracea	cauliflower	+++ *	+++++	++++	+++ **
Brassica oleracea	leaf cabbage	0/+	0/+	+++++	+++ **
Capsicum annuum	chilli pepper	++++	+++++	+++	+++++
Capsicum annuum	bird pepper	++++	+++++	+	++
Capsicum annuum	aromatic hot pepper	+++	+++++	+	++
Capsicum annuum	sweet pepper	++++ *	+++++	++++	++++
Celosia argentea	celosia	+++++	++	0	+
Citrullus lanatus	watermelon	+++	+++++	+++++	+++++
Citrullus lanatus	egusi melon	+++++	+++++	0	0
Cleome gynandra	spiderplant	0	0	++++	+++
Corchorus olitorius	jew's mallow	+++++	++++	+++	++++
Cucumis melo	melon	+++	++++	+++	+++
Cucumis sativus	cucumber	++++	+++++	+++	+++
Cucurbita maxima	pumpkin	+++	+++++	++++	+++
Cucurbita moschata	musk pumpkin	+++	+++++	+++	+++
Cucurbita pepo	courgette	+++	+++++	+++	+++ **
Daucus carota	carrot	+++ *	+++++	++++	++++ **
Hibiscus sabdariffa	roselle	+++	+++++	0	+
Lactuca sativa	lettuce	++++	+++++	+++++	+++
Lagenaria siceraria	bottle gourd	++	++++	++	++++
Lycopersicon esculentum	tomato	+++++*	+++++	+++++	+++++
Moringa oleifera	drumstick tree	+	+++++	+	+++
Phaseolus vulgaris	French bean	+++	+++++	+++++	++++ **
Raphanus sativus	radish	++	++++	++	+
Solanecio biafrae	worowo	++++	+	0	0
Solanum aethiopicum	garden egg (Gilo Group)	+++++	+++	++	++++
Solanum aethiopicum	ndrowa (Kumba Group)	++	+++++	0	0
Solanum macrocarpon	gboma	++++	++	0	+
Solanum melongena	eggplant	+++	+++++	++++	++++
Solanum spp.	African nightshades	++++	++++	+++++	++++
Talinum triangulare	waterleaf	++++	++	0	0
Telfairia occidentalis	fluted pumpkin	+++++	+++	0	0
Vernonia amygdalina	bitterleaf	+++++	+++	0	0
Vigna unguiculata	cowpea (leaves)	+++	++++	+++	++++

0 absent; + rare; ++ occasional; +++ common; ++++ important; +++++ frequent, large quantities.
* = supply from savanna area, northern Nigeria (shallot and tomato also from southern Nigeria);
** = supply from highland Kenya.

Properties

Vegetables are eaten for their flavour (relishes) and nutritional value. The content of micronutrients (vitamins, minerals) is of major importance, but in many cases also the macronutrients (carbohydrate, protein, fat) contribute considerably to the nutritional value of the meal. The nutrients that are essential components of the diet are listed in the species accounts. The analytical method used to determine the various elements of the nutritional composition considerably influences the values found. For this reason a few standard sources were used wherever possible and the sources are mentioned in the text. These sources are: McCance & Widdowson's The composition of foods; the USDA Nutrient database for standard reference; FAO Food composition table for use in Africa.
Apart from nutrients, the properties include compounds with possible or proven medicinal value, toxins and other relevant chemical compounds.

Description

A morphological characterization of the species is given. The description is in 'telegram' style and uses botanical terms. Providing a description for the general public is difficult as more generally understood terms often lack the accuracy required in a botanical description. A line drawing is added for all major and some lesser-known species to complement and visualize the description.

Management

Descriptions of husbandry methods including fertilizer application, irrigation and pest and disease control measures are given under 'Management' and under 'Diseases and pests'. These reflect actual practices or generalized recommendations, opting for a broad overview but without detailed recommendations adapted to the widely varying local conditions encountered by farmers. Recommendations on chemical control of pests and diseases are merely indicative and local regulations should be given precedence. PROTA will participate in the preparation of derived materials for extension and education, for which the texts in this volume provide a basis, but to which specific local information will be added.

Genetic resources

The genetic diversity of many plant species in Africa is eroding, sometimes at an alarming rate, as a consequence of habitat destruction and overexploitation. The replacement of landraces of cultivated species by modern cultivars marketed by seed companies is another cause of genetic erosion. Reviews are given of possible threats for plant species and of the diversity within species. Information on ex-situ germplasm collections is mostly extracted from publications of the International Plant Genetic Resources Institute.

Breeding

In comparison with other parts of the world, little breeding work aiming specifically at conditions in Africa has been done and few seed companies offer seed of locally adapted cultivars. Large differences exist in the occurrence of landraces, and local production of exotic vegetables, e.g. tomato, carrot and onion, is more based on farm-saved seed in West Africa than in East Africa, where the seed is more often imported. However, French bean seed in West Africa is mostly imported, while in East Africa it is locally produced. Seed of white headed cabbage is almost exclusively imported in all countries. Seed companies offering locally adapted cultivars, either bred in situ or elsewhere in the tropics for comparable conditions, are mentioned. Citing a cultivar does not imply a recommendation.

References

The main objective of the list of references given is to guide readers to additional information; it is not intended to be complete or exhaustive. Authors and editors have selected major and other references; major references are limited to 10 references (5 for minor species), the number of other references is limited to 20 (10 for minor species). The references listed include those used in writing the account. Where data available on the Internet have been used, the website and date are also cited.

Alphabetical treatment of vegetables

ABELMOSCHUS CAILLEI (A.Chev.) Stevels

Protologue Bull. Mus. natn. Hist. nat., Paris, sér. 4, 10, sect. B, Adans., 2: 138 (1988).

Family Malvaceae

Chromosome number $2n$ = 184–200

Synonyms *Hibiscus manihot* L. var. *caillei* A.Chev. (1940), *Hibiscus manihot* auct. non L., *Abelmoschus manihot* auct. non (L.) Medik., *Hibiscus esculentus* auct. non L., *Abelmoschus esculentus* auct. non (L.) Moench.

Vernacular names West African okra, West African okro (En). Gombo ouest-africain, gumbo ouest-africain (Fr).

Origin and geographic distribution The genus *Abelmoschus* originated in South-East Asia. West African okra, however, is a cultigen occurring mainly in West and Central Africa. It has been reported from Guinea to Nigeria in West Africa, in Cameroon, Gabon and DR Congo in Central Africa, and in Uganda in East Africa. Its distribution is restricted to humid and perhumid climates in Africa, between 12°N and 12°S, most commonly between 5°N and 10°N, whereas the common okra (*Abelmoschus esculentus* (L.) Moench) can be found worldwide throughout the tropics, subtropics and warm temperate regions.

Uses Young immature fruits are an important vegetable, consumed cooked or fried. In West Africa they are usually boiled in water to make slimy soups and sauces. Fruits can be dried, whole or sliced, and subsequently conserved. Before selling, the dried product is usually ground to a powder. Young leaves are sometimes consumed as spinach.

There are no apparent differences in uses between West African and common okra. The extent to which the uses mentioned below apply to West African okra is unknown. Leaves are considered good cattle feed, but this is seldom compatible with the plant's primary use for human consumption. Okra mucilage is suitable for medicinal and industrial applications. It has been used as a blood plasma replacement or blood volume expander. Leaves are sometimes used as a basis for poultices, as an emollient, sudorific or antiscorbutic and to treat dysuria. Okra mucilage has been added as size to glaze paper, and is used in confectionery. The bark contains a fibre which is suitable for spinning into rope and for paper and cardboard manufacture. The fibre has been locally used for fishlines and game traps, but fibre harvesting is incompatible with fruit harvesting. Roasted seeds of okra are used in some areas as a substitute for coffee.

Abelmoschus caillei – planted

Production and international trade World production of okra (both species) as fresh fruit-vegetable is estimated at 6 million t/year. Okra production in West and Central Africa is estimated at 500,000–600,000 t annually based on available consumption data. West African okra is estimated to make up half this amount, about 5% of total world production of okra.

Properties No studies suggest systematic differences in nutritional value between the two okra species. The composition of okra fruits per 100 g edible portion (81% of the product as purchased, ends trimmed) is: water 88.6 g (85.7–90.2), energy 144 kJ (36 kcal), protein 2.1 g (1.1–3.0), fat 0.2 g, carbohydrate 8.2 g, fibre 1.7 g, Ca 84 mg (55–142), P 90 mg, Fe 1.2 mg (1.1–1.5), β-carotene 185 μg (180–190), thiamin 0.04 mg, riboflavin 0.08 mg, niacin 0.6 mg, ascorbic acid 47 mg (20–126). The composition of okra leaves per 100 g edible portion is: water 81.5 g (75.3–92.4), energy 235 kJ (56 kcal), protein 4.4 g (2.8–5.6), fat 0.6 g, carbohydrate 11.3 g, fibre 2.1 g, Ca 532 mg (258–635), P 70 mg, Fe 0.7 mg, β-carotene 385 μg, thiamin 0.25 mg, riboflavin 2.8 mg, niacin 0.2 mg, ascorbic acid 59 mg (9–75) (Leung, W.-T.W., Busson, F. & Jardin, C., 1968).

Carbohydrates are mainly present in the form of mucilage. That of the young fruits of *Abelmoschus esculentus* consists of long-chain molecules with a molecular weight of about 170,000 made up of sugar units and amino acids. The main components are galactose (25%), rhamnose (22%), galacturonic acid (27%) and amino acids (11%). The mucilage is highly soluble in water. Its solution in water has an intrinsic viscosity value of about 30.

Okra seeds contain about 20% protein (similar in amino acid composition to soya bean protein) and 20% oil (similar in fatty acid composition to cotton-seed oil). The bark fibre is easy to extract. It is white to yellow in colour, strong but rather coarse.

Tests conducted in China suggest that an alcohol extract of *Abelmoschus* leaves can eliminate oxygen free radicals, alleviate renal tubular-interstitial diseases, improve renal function and reduce proteinuria.

Description Stout, annual to biennial, erect herb up to 4 m tall, mostly strongly branched; stem often woody at base, terete, glabrous or with scattered, stiff hairs, often red-blotched; branches erect to curved downwards. Leaves arranged spirally, simple, variable in shape and size; stipules filiform, up to 2 cm long, covered with stiff hairs, especially on the margins; petiole up to 60 cm long, often red-tinged, with a line of soft, simple hairs on the upper side, otherwise glabrous or with scattered, stiff hairs; blade transversally elliptical to orbicular in outline, up to 50 cm broad, length of midrib up to 35 cm, mostly 3-, 5- or 7-palmatilobed to palmatipartite, cordate at base, 5–9-veined, segments triangular, ovate, elliptical, obovate, oblong, spatulate or lanceolate, acuminate, serrate to crenate, sometimes entire or angular, veins on both sides with scattered, stiff hairs. Flowers axillary, solitary or racemose by reduction or abortion of the upper leaves; pedicel up to 4.5 cm long in flower, up to 13 cm in fruit, glabrous or with scattered, stiff hairs; epicalyx segments 5–10, free, ovate to oblong, 10–35 mm × 4–13 mm, acute to acuminate, generally persistent through early fruit development, covered with stiff hairs, especially on the margins; calyx spathaceous, 2–7 cm long, 5-toothed apically, usually splitting on one side at the expansion of the corolla, adnate to and caducous with the corolla and staminal column, sericeous outside, often mixed with short, simple and stellate hairs, strigose to sericeous inside; petals 5, free, obovate to orbicular, 4–9 cm long, base fleshy, apex obtuse to retuse, glabrous, yellow, often turning pink after anthesis, with a dark purple centre; stamens united into a staminal column up to 3.5 cm long, white, glabrous; ovary superior, tomentose, often with some stiff hairs on the costae as well, 5–12 style arms 3–5 mm long, stigmas dark purple, with simple hairs. Fruit an erect to drooping, ovoid capsule 5–25 cm × 1–5 cm, acuminate, terete to 5–12-angled, concave between the costae, gradually losing its original indumentum, when young varying in colour from purple-red and reddish-green to dark green, and from pale green to yellow, completely or partially loculicidal or not opening at all, up to 100-seeded. Seeds globose to ovoid, 3–5 mm in diameter, with minute warts in concentric rows, rarely with long red hairs on the seed coat. Seedling with epigeal germination.

Abelmoschus caillei – 1, top of flowering plant; 2, flowering branchlet; 3, young fruit; 4, mature fruit; 5, seed.
Redrawn and adapted by W. Wessel-Brand

Other botanical information This taxon was described as a species in 1988 although it is only known from cultivated material. Classification as a cultivar-group might have been more appropriate. There are strong indications that *Abelmoschus caillei* is an amphidiploid of *Abelmoschus esculentus* (L.) Moench ($2n$ = 130–140) and *Abelmoschus manihot* (L.) Medik. ($2n$ = 60–68). However, the latter species has not been found with certainty in the area of distribution of West African okra, and isozyme analysis has neither confirmed nor rejected the relationships. *Abelmoschus manihot* differs from *Abelmoschus caillei* by a smaller number of epicalyx segments (4–8), and much smaller fruits (3.5–6 cm long) which are inedible because they are covered with prickly hairs. *Abelmoschus esculentus* differs in several respects from *Abelmoschus caillei*, but the epica-

lyx offers the best discriminating characteristic: the width of the epicalyx segments is 4–13 mm in *Abelmoschus caillei* and 0.5–3 mm in *Abelmoschus esculentus*. The two okra species can be quite reliably (but not with absolute certainty) recognized on the basis of fruit form. Fruits of *Abelmoschus caillei* are ovoid, whereas fruits of *Abelmoschus esculentus* are cylindrical to pyramidal.
The list of synonyms shows that information related to *Abelmoschus caillei* has often been attributed to *Abelmoschus esculentus* and/or *Abelmoschus manihot*, thus literature has to be interpreted with care.

Growth and development Under the conditions of southern Côte d'Ivoire (5°N), West African okra flowers within 50–110 days after sowing in the dry season (sowing in October: days shortening) and within 65–270 days after sowing in the rainy season (sowing in March: days lengthening). Short-day types, planted at the beginning of the rains (March), do not flower by the end of the rainy season (November), but are vegetatively so well-developed that they easily survive the dry season without supplementary water, and flower and bear fruit in a period of scarcity. In African languages, West African okra is therefore sometimes referred to as 'late okra' or 'dry-season okra'. Crop duration thus shows enormous variation depending on cultivar, locality and season, and varies from 4 months to well over 12 months.
Comparing cultivars of similar earliness, it is striking that West African okra has a considerably longer productive period than cultivars of common okra. This is an attractive feature for home garden planting.
Flower opening and pollination take place in the early morning. Although basically a self-pollinated crop, considerable cross-pollination by insects may take place. For vegetable use the fruits are picked about one week after anthesis. The regular removal of young fruits permits sustained vegetative growth and flowering, prolonging the productive period. In a seed crop, it takes about one month from anthesis to fruit maturity. In this case, vegetative growth stops soon after anthesis, all assimilates being diverted to reproductive parts.

Ecology Many local types show a qualitative short-day response even at a latitude of only 5°, the shortest critical daylength reported being 12 hours 15 minutes. Even at this latitude, vegetative periods of 8–9 months occur when sown under the 'long-day' conditions of the rainy season. Apart from these qualitative responses, most local types show quantitative short-day responses. West African okra is, therefore, not suitable for semi-arid and arid regions beyond latitudes of 12°N and 12°S because of daylength requirements.
West African okra tolerates a wide variety of soils but prefers well-drained sandy loams, with pH 6–7, and a high content of organic matter.

Propagation and planting Most farmers harvest seed from their own local cultivar or rather heterogeneous landrace. The easiest way to keep the seed is to leave it in the pods. Seed weight varies from 30–70 g/1000 seeds. Prior to sowing the seed is often soaked in water to soften the hard seed coat. It is usually dibbled directly in the field (1–3 seeds per hole). The robust West African okra should be grown at 20,000–50,000 plants/ha. Emergence is within one week. When the plants are about 10 cm tall, they are thinned to one plant per hole.
Germination and initial growth are improved greatly by cultural practices that lower soil temperature, e.g. mulching, watering before the hottest part of the day, and sowing on ridge sides least exposed to direct sunlight.

Management Commercial okra growers usually practise sole cropping, and prefer the early, homogeneous, introduced cultivars of common okra (*Abelmoschus esculentus*). In traditional agriculture, farmers grow their okra landraces in home gardens or in fields with other food crops. The landraces often consist of a mixture of *Abelmoschus caillei* and *Abelmoschus esculentus*, the former being predominant in humid climates, the latter in drier climates.
The uptake of minerals is rather high. Indicative figures for total nutrient uptake per ha of a crop with fruit yield of about 10 t/ha are 100 kg N, 10 kg P, 60 kg K, 80 kg Ca and 40 kg Mg. Under humid tropical conditions a full-grown crop consumes about 8 mm of water per day.
Some farmers practise ratoon cropping. A ratoon crop flowers soon after cutting, but usually results in poor quality fruit with a high percentage of bent fruits.

Diseases and pests West African okra is more tolerant of diseases and pests than common okra. An exception is vascular wilt (*Fusarium oxysporum*), which in West African okra has more time to manifest itself due to the longer crop duration. Other serious fungal diseases of okra in West Africa are damping-off

(*Macrophomina phaseolina*) and Cercospora blight (*Cercospora abelmoschi*). *Oidium abelmoschi* is more important in the drier climates.

Okra mosaic virus (OkMV), transmitted by flea beetles (*Podagrica*), is widespread but damage is much less important than that caused by leaf curl, transmitted by whitefly (*Bemisia tabaci*). These viruses must be controlled through control of the vectors. Nematodes of the genus *Meloidogyne* constitute a major problem. Damage by nematodes is avoided by crop rotation, e.g. with Guinea grass (*Panicum maximum* Jacq.) or cereals, and by large applications of organic manure.

Insect damage is mainly due to the cricket *Brachytrupes membranaceus*, to *Podagrica* flea beetles, to the bollworms *Earias biplaga* and *Pectinophora gossypiella*, and to the beetle *Anomala denuda*. Chemical control of insects is hazardous because crop harvesting is frequent.

Harvesting The earliest types of West African okra are ready for first harvest at 8 weeks after sowing. Developing fruits should be harvested when 7–8 days old. Earlier picking depresses yields because of low fruit weight, but delayed picking depresses marketable yields because over-aged fruits become fibrous. Okra fields are, therefore, harvested at intervals of 2–3 days. The minimum frequency is once a week but then fruits of all sizes have to be picked. Although such a low frequency reduces yield, the very small fruits can fetch a higher price, being of prime quality. For seed production, the whole crop can be harvested once-over. Intensive contact with the slightly hairy fruits and plants may lead to skin irritation.

Yield A vegetable yield of 10 t/ha can be considered a good harvest, but yields of over 40 t/ha can be realized under optimal conditions. Yields are usually low (2–4 t/ha) as a result of non-intensive growing methods. Seed yields are in the range of 500–1000 kg/ha.

Handling after harvest Fresh okra can be transported quite easily in bulk and kept for a few days without much loss of quality. Dried okra is an important product in West Africa.

Okra mucilage can be obtained by grinding plant material, removing waxes and fat with ether and alcohol, suspending the purified material in water, filtering and concentrating the filtrate.

Genetic resources Local landraces are not at great risk of genetic erosion at present. Only commercial growers tend to switch to commercial cultivars of *Abelmoschus esculentus*, whereas *Abelmoschus caillei* is ubiquitous in subsistence farming.

Substantial germplasm of West African okra is maintained by CNRA (Centre National de Recherches Agronomiques) in Bouaké (Côte d'Ivoire) and by IRD (Institut de Recherche pour le Développement) in Montpellier (France). Many national collections contain both okra species, curators often not being aware of the difference. West African okra has already been introduced into several American and Asian countries for research purposes through germplasm exchange.

West African okra is reported to be resistant to yellow vein mosaic virus (YVMV), a major cause of crop failure of common okra in Asia, whitefly (*Bemisia tabaci*) being the vector.

Breeding Selection and breeding of West African okra have not been carried out by the commercial sector, but African farmers have selected an enormous diversity of forms which fit into a great variety of cropping systems. There is, however, plenty of scope for combining desirable characteristics in cultivars for the traditional sector (where hardy, robust, long-lived types are required) as well as for the commercial sector (where good alternatives for introduced cultivars of *Abelmoschus esculentus* are needed with better adaptation to local conditions, diseases and pests in particular). Nevertheless, isozyme analysis has shown a rather low level of genetic diversity in cultivated okra in spite of much phenotypic variability.

The characteristics of both okra species open up new opportunities for recombination. They cross readily in both directions and crosses result in vigorous hybrids; these, however, show a marked reduction in fertility. Nevertheless, seed is formed by interspecific hybrids under conditions of open pollination, probably due to backcrossing with fertile pollen of one of the parental species. *Abelmoschus esculentus* 'Parbhani Kranti' was bred in this way in India, with YVMV resistance/tolerance derived from *Abelmoschus caillei*.

Although they occur together in farmers' fields, the genetic integrity of the two okra species is largely assured because chances are very small that the unproductive F_1 hybrids will be selected as seed sources for the next crop.

Prospects Okra will remain a welcome, productive fruit-vegetable. The relatively recent discovery that West African okra is different from common okra offers new possibilities in an old crop.

Major references Charrier, A., 1984; Hamon, S., 1988; Hamon, S. & Charrier, A., 1997;

Hamon, S. & Hamon, P., 1991; IBPGR, 1991; Markose, B.L. & Peter, K.V., 1990; Schippers, R.R., 2000; Siemonsma, J.S., 1982a; Siemonsma, J.S., 1982b; Stevels, J.M.C., 1988.

Other references Burkill, H.M., 1997; Chevalier, A., 1940; Hamon, S. & van Sloten, D.H., 1995; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Martin, F.W. & Ruberté, R.M., 1978; Siemonsma, J.S., 1991; Stevels, J.M.C., 1990; Tomoda, M. et al., 1980; van Borssum-Waalkes, J., 1966.

Sources of illustration Siemonsma, J.S., 1982a; Stevels, J.M.C., 1990.

Authors J.S. Siemonsma & S. Hamon

ABELMOSCHUS ESCULENTUS (L.) Moench

Protologue Methodus: 617 (1794).

Family Malvaceae

Chromosome number $2n = (66-)130(-144)$

Synonyms *Hibiscus esculentus* L. (1753).

Vernacular names Common okra, okra, okro, lady's finger (En). Gombo commun, gombo, gumbo (Fr). Quiabeiro (Po). Mbamia, mbinda (Sw).

Origin and geographic distribution The genus *Abelmoschus* originated in South-East Asia. *Abelmoschus esculentus*, however, is a cultigen of uncertain origin. It is widespread in tropical, subtropical and warm temperate regions, but is particularly popular in West Africa, India, the Philippines, Thailand and Brazil. *Abelmoschus esculentus* has been reported from the whole of tropical Africa, whereas West African okra (*Abelmoschus caillei* (A.Chev.) Stevels) is restricted to the humid and perhumid climates of Africa.

Abelmoschus esculentus – planted

Uses Young immature fruits are an important vegetable, consumed cooked or fried. In West Africa they are usually boiled in water to make slimy soups and sauces. The fruits can be conserved by drying, whole or sliced, or by pickling. Before selling, the dried product is usually ground to powder. Young leaves are commonly used as spinach. The leaves are sometimes used as cattle feed.

Okra mucilage is suitable for medicinal and industrial applications. It has been used as a plasma replacement or blood volume expander. Leaves are sometimes used as a basis for poultices, as an emollient, sudorific or antiscorbutic and to treat dysuria. Okra mucilage has been added as size to glaze paper and is used in confectionery. The bark fibre has been locally used for fishlines and game traps. It is suitable for spinnning into rope and for paper and cardboard manufacture. Roasted okra seeds are used in some areas as a substitute for coffee.

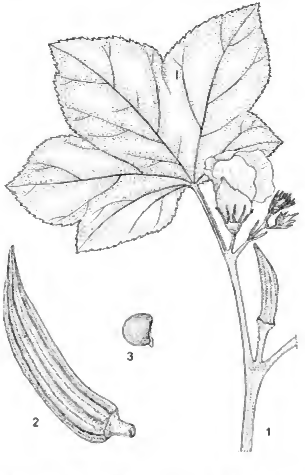
Production and international trade World production of okra (both species) as fresh fruit-vegetable is estimated at 6 million t/year. Common okra makes up 95% of this amount. It is only in West and Central Africa (accounting for about 10% of world production) that common okra and West African okra are both used. They share the market roughly fifty-fifty.

Properties The composition of okra fruits per 100 g edible portion (81% of the product as purchased, ends trimmed) is: water 88.6 g (85.7–90.2), energy 144 kJ (36 kcal), protein 2.1 g (1.1–3.0), fat 0.2 g, carbohydrate 8.2 g, fibre 1.7 g, Ca 84 mg (55–142), P 90 mg, Fe 1.2 mg (1.1–1.5), β-carotene 185 μg (180–190), thiamin 0.04 mg, riboflavin 0.08 mg, niacin 0.6 mg, ascorbic acid 47 mg (20–126). The composition of okra leaves per 100 g edible portion is: water 81.5 g (75.3–92.4), energy 235 kJ (56 kcal), protein 4.4 g (2.8–5.6), fat 0.6 g, carbohydrate 11.3 g, fibre 2.1 g, Ca 532 mg (258–635), P 70 mg, Fe 0.7 mg, β-carotene 385 μg, thiamin 0.25 mg, riboflavin 2.8 mg, niacin 0.2 mg, ascorbic acid 59 mg (9–75) (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). Compared to other fleshy fruit-vegetables (tomato, eggplant), okra is particularly rich in Ca and ascorbic acid.

Carbohydrates are mainly present in the form of mucilage. That of young fruits consists of long-chain molecules with a molecular weight of about 170,000 made up of sugar units and amino acids. The main components are galactose (25%), rhamnose (22%), galacturonic acid (27%) and amino acids (11%). The mucilage is highly soluble in water. Its solution in water

has an intrinsic viscosity value of about 30. Okra seeds contain about 20% protein (similar in amino acid composition to soya bean protein) and 20% oil (similar in fatty acid composition to cotton-seed oil). The bark fibre is easy to extract. It is white to yellow in colour, strong but rather coarse. Tests conducted in China suggest that an alcohol extract of *Abelmoschus* leaves can eliminate oxygen free radicals, alleviate renal tubular-interstitial diseases, improve renal function and reduce proteinuria.

Description Stout, annual, erect herb up to 4 m tall, more or less strongly branched; stem terete, with scattered, stiff hairs, glabrescent, often red-blotched; branches erect to curved downwards. Leaves arranged spirally, simple, variable in shape and size; stipules filiform, up to 2 cm long, often split to the base, covered with stiff hairs; petiole up to 50 cm long, often red-tinged, with a line of soft, simple hairs on the upper side, otherwise with scattered, stiff hairs and glabrescent; blade transversally elliptical to orbicular in outline, up to 50 cm broad, length of midrib up to 35 cm, mostly 3-, 5- or 7-palmatilobed to palmatipartite, cordate at base, 5–9-veined, segments triangular, ovate, elliptical, obovate, oblong, spatulate or lanceolate, acuminate, serrate to crenate, sometimes entire or angular, veins on both sides with scattered, stiff hairs, glabrescent. Flowers axillary, solitary or racemose by reduction or abortion of the upper leaves; pedicel up to 3 cm long in flower, up to 7 cm in fruit, with scattered, stiff hairs, glabrescent; epicalyx segments 7–15, free, linear to lanceolate, 5–25 mm × 0.5–3 mm, acute to acuminate, caducous at flowering or soon after, covered with stiff hairs; calyx spathaceous, 2–6 cm long, 5-toothed apically, usually splitting on one side at the expansion of the corolla, adnate to and caducous with the corolla and staminal column, strigose to sericeous; petals 5, free, obovate to orbicular, 3–7 cm long, base fleshy, apex obtuse to retuse, glabrous, yellow, often turning pink after anthesis, with a dark purple centre; stamens united into a staminal column up to 2.5 cm long, white, glabrous; ovary superior, tomentose, often with some stiff hairs on the costae as well, 5–10 style arms 3–5 mm long, stigmas dark purple, with simple hairs. Fruit an erect, cylindrical to pyramidal capsule 5–25 cm × 1–5 cm, acuminate, terete to 5–10-angled, concave between the costae, gradually losing its original indumentum, when young varying in colour from purple-red and reddish-green to dark green, and from pale green to yellow, completely or partially loculicidal or not opening at all, up to 100-seeded. Seeds globose to ovoid, 3–6 mm in diameter, with minute warts in concentric rows, rarely with long red hairs on the seed coat. Seedling with epigeal germination.



Abelmoschus esculentus – 1, flowering and fruiting shoot; 2, fruit; 3, seed.
Redrawn and adapted by Iskak Syamsudin

Other botanical information *Abelmoschus esculentus* (usually $2n = 130$) is probably an amphidiploid (allotetraploid), derived from *Abelmoschus tuberculatus* Pal & H.B.Singh ($2n = 58$), a wild species from India, and a species with $2n = 72$ chromosomes (possibly *Abelmoschus ficulneus* (L.) Wight & Arn. ex Wight).
Another edible okra species, *Abelmoschus caillei* (A.Chev.) Stevels, occurs in the humid parts of West and Central Africa. There are strong indications that also *Abelmoschus caillei* is an amphidiploid with *Abelmoschus esculentus* being one of the parental species.
There are no apparent differences in use between the common and West African okra, which is why they are often lumped together. Morphologically *Abelmoschus caillei* differs in several respects from *Abelmoschus esculentus*,

but the epicalyx offers the best discriminating characteristic: the width of the epicalyx segments is 0.5–3 mm in *Abelmoschus esculentus* and 4–13 mm in *Abelmoschus caillei*. The two okra species can be quite reliably (but not with absolute certainty) recognized on the basis of fruit form. Fruits of *Abelmoschus esculentus* are cylindrical to pyramidal, whereas fruits of *Abelmoschus caillei* are ovoid. Literature references on common okra have to be interpreted with care because they may include information related to *Abelmoschus caillei*.

There are many cultivars of common okra. Some of the better known are 'Clemson Spineless', 'Indiana', 'Emerald' (United States) and 'Pusa Sawani' (India), which have been in use for about 30 years.

Growth and development Under the conditions of southern Côte d'Ivoire (5°N), local and introduced cultivars flower within 45–80 days after sowing in the dry season (sowing in October: days shortening) and within 55–105 days after sowing in the rainy season (sowing in March: days lengthening). Crop duration rarely exceeds 6 months.

Flower opening and pollination take place in the early morning. Although basically a self-pollinated crop, considerable cross-pollination by insects may take place. For vegetable use the fruits are picked about one week after anthesis. The regular removal of young fruits permits sustained vegetative growth and flowering, prolonging the productive period. In a seed crop, it takes about one month from anthesis to fruit maturity. In this case, vegetative growth stops soon after anthesis, all assimilates being diverted to the reproductive plant parts.

Ecology *Abelmoschus esculentus* needs temperatures above 20°C for normal growth and development. Germination percentage and speed of emergence are optimal at 30–35°C. Flower initiation and flowering are delayed with increasing temperatures (positive correlation between temperature and number of vegetative nodes). *Abelmoschus esculentus* is a short-day plant, but its wide geographical distribution (up to latitudes of 35–40°) indicates that cultivars differ markedly in sensitivity. Flower initiation and flowering are hardly affected by daylength in popular subtropical cultivars such as 'Clemson Spineless' and 'Pusa Sawani'. Most tropical cultivars show quantitative short-day responses, but qualitative responses also occur. The shortest critical daylength reported is 12 hours 30 minutes. This explains why flowering of local cultivars of common okra is only quantitatively affected by daylength in the coastal areas of the Gulf of Guinea (5°N). However, more inland at higher latitudes (10°N) one can occasionally observe very tall non-flowering plants of common okra due to a qualitative response.

Common okra tolerates a wide variety of soils but prefers well-drained sandy loams, with pH 6–7, and a high content of organic matter.

Propagation and planting Most farmers harvest seed from their own local cultivar or rather heterogeneous landrace. The easiest way to keep the seed is to leave it in the pods. Seed weight varies from 30–80 g/1000 seeds. To soften the hard seed coat, the seed is often soaked in water or chemicals prior to sowing. The seed is usually dibbled directly in the field (1–3 seeds per hole). Optimum plant densities are in the range of 50,000–150,000 plants/ha. Emergence is within one week. When the plants are about 10 cm tall, they are thinned to one plant per hole.

Germination and initial growth are improved greatly by cultural practices that lower soil temperature, e.g. mulching, watering before the hottest part of the day, and sowing on ridge sides least exposed to direct sunlight.

Management Commercial okra growers usually practise sole cropping, and prefer the early, homogeneous, introduced cultivars. In traditional agriculture, farmers grow their okra landraces in home gardens or in fields with other food crops. In West and Central Africa the landraces often consist of a mixture of *Abelmoschus esculentus* and *Abelmoschus caillei*, the former being predominant in dry climates, the latter in humid climates.

The uptake of minerals is rather high. Indicative figures for total nutrient uptake per ha of a crop with a fruit yield of about 10 t/ha are 100 kg N, 10 kg P, 60 kg K, 80 kg Ca and 40 kg Mg.

Under humid tropical conditions a full-grown crop consumes about 8 mm of water per day.

Some farmers practise ratoon cropping. A ratoon crop flowers soon after cutting, but usually results in poor quality fruit with a high percentage of bent fruits.

Diseases and pests The most serious fungal diseases of okra in Africa are damping-off (*Macrophomina phaseolina*, *Pythium aphanidermatum*, *Rhizoctonia solani*), vascular wilt (*Fusarium oxysporum*), Cercospora blight (*Cercospora abelmoschi*, *Cercospora malayensis*) and powdery mildew (*Erysiphe cichoracearum*,

Oidium abelmoschi).
Okra mosaic virus (OkMV), transmitted by flea beetles (*Podagrica*), is widespread in Africa but damage is much less important than that caused by okra leaf curl disease (OLCV), transmitted by whitefly (*Bemisia tabaci*). Whitefly is also the vector of yellow vein mosaic virus (BYVMV), a major cause of crop failure in Asia. These viruses can only be controlled through control of the vectors. Nematodes of the genus *Meloidogyne* constitute a major problem. Damage by nematodes is avoided by crop rotation (e.g. with cereals) and by large applications of organic manure.
Important pests are fruit and stem borers (*Earias* spp. and *Heliothis* spp., *Pectinophora gossypiella*), flea beetles (*Podagrica* spp.) and jassids (*Empoasca* spp.). Chemical control is hazardous because crop harvesting is frequent. Common okra is in general more seriously affected by diseases and pests than West African okra.

Harvesting The earliest types of common okra are ready for first harvest at 7 weeks after sowing. Fruits should be harvested when 7–8 days old. Earlier picking depresses yields because of low fruit weight, but delayed picking depresses marketable yields because over-aged fruits become fibrous. Okra fields are, therefore, harvested at intervals of 2–3 days. The minimum frequency is once a week but then fruits of all sizes have to be picked. Although such a low frequency reduces yield, the very small fruits can fetch a higher price, being of prime quality. For seed production, the whole crop can be harvested once-over. Intensive contact with the slightly hairy fruits and plants may lead to skin irritation.

Yield A vegetable yield of 10 t/ha can be considered a good harvest, but yields of over 40 t/ha can be realized under optimal conditions. Yields are usually low (2–4 t/ha) as a result of non-intensive growing methods. Seed yields are in the range of 500–1000 kg/ha.

Handling after harvest Fresh okra can be transported quite easily in bulk and kept for a few days without much loss of quality. Dried okra is an important product in West Africa. Although usually sliced transversally, longitudinal slicing has been observed in Benue State, Nigeria. Such slices dry well at the edges but start fermenting from the middle, creating a unique flavour. Some countries have a small canning and freezing industry.
Okra mucilage can be obtained by grinding plant material, removing waxes and fat with ether and alcohol, suspending the purified material in water, filtering and concentrating the filtrate.

Genetic resources Local landraces in Africa are not at great risk of genetic erosion at present. Only commercial growers tend to switch to commercial cultivars of common okra, whereas local landraces of both okra species are ubiquitous in subsistence farming.
Germplasm base collections are maintained by the Southern Regional Plant Introduction Station (Griffin, Georgia, United States), NHR (National Horticultural Research Institute, Ibadan, Nigeria), IRD (Institut de Recherche pour le Développement, Montpellier, France), CNRA (Centre National de Recherches Agronomiques, Bouaké, Côte d'Ivoire), NBPGR (National Bureau for Plant Genetic Resources, New Delhi, India) and IPB (Institute of Plant Breeding, Los Baños, the Philippines).

Breeding In Africa selection and breeding of common okra have only been carried out to a limited scale by the commercial sector. Technisem Seed Company in Senegal distributes improved African cultivars, e.g. 'Volta' suitable for the hot and cool season, and the F_1 hybrid 'Lima' with high tolerance to virus diseases and suitable for export. African farmers have selected an enormous diversity of forms which fit within a great variety of cropping systems. Some of these are available from local seed houses. International breeding work has been oriented towards intensive cultivation with high production in a short period (early maturity, compact plants with short internodes, high-density planting) and wide adaptation (photoperiod insensitivity, resistance to pests and diseases). Crossing between promising parents combined with pedigree selection or backcrossing remains the most common breeding procedure. Several attractive American and Indian cultivars have found their way to commercial growers throughout the tropics and subtropics, but there is still plenty of scope for cultivar improvement in Africa for the commercial sector (where good alternatives for the introduced cultivars are needed with better adaptation to local conditions) as well as for the traditional sector (where hardy, robust, long-lived types are required). Nevertheless, isozyme analysis has shown a rather low level of genetic diversity in cultivated okra in spite of much phenotypic variability. There is little information on improvement using biotechnology apart from in-vitro DNA extraction and plant regeneration from various explants and

callus tissue.
The characteristics of both okra species open up new opportunities for recombination. They cross readily in both directions and crosses result in vigorous hybrids; these, however, show a marked reduction in fertility. Nevertheless, seed is formed by interspecific hybrids under conditions of open pollination, probably due to backcrossing with fertile pollen of one of the parental species. 'Parbhani Kranti' was bred in this way in India, with YVMV resistance/tolerance derived from *Abelmoschus caillei*.
Although occurring together in farmers' fields in West Africa, the genetic integrity of the two okra species is largely assured because chances are very small that the unproductive F_1 hybrids will be selected as seed sources for the next crop.

Prospects Okra will remain a welcome, productive fruit-vegetable. The relatively recent discovery that West African okra is different from common okra offers new possibilities in an old crop. Okra improvement will also greatly benefit from a better understanding of the phylogeny and species relations within the genus *Abelmoschus*.

Major references Charrier, A., 1984; Düzyaman, E., 1997; Hamon, S., 1988; Hamon, S. & Charrier, A., 1997; Hamon, S. & Hamon, P., 1991; IBPGR, 1991; Schippers, R.R., 2000; Siemonsma, J.S., 1982a; Siemonsma, J.S., 1982b; Stevels, J.M.C., 1988.

Other references Burkill, H.M., 1997; Chevalier, A., 1940; Hamon, S. & van Sloten, D.H., 1995; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Markose, B.L. & Peter, K.V., 1990; Martin, F.W. & Ruberté, R.M., 1978; Siemonsma, J.S., 1991; Stevels, J.M.C., 1990; Tomoda, M. et al, 1980; van Borssum-Waalkes, J., 1966.

Sources of illustration Stevels, J.M.C., 1990.

Authors J.S. Siemonsma & C. Kouamé
Based on PROSEA 8: Vegetables.

ACALYPHA BIPARTITA Müll.Arg.

Protologue Flora 47: 538 (1864).

Family Euphorbiaceae

Synonyms *Ricinocarpus bipartitus* (Müll. Arg.) Kuntze (1891).

Vernacular names Mhacha (Sw).

Origin and geographic distribution *Acalypha bipartita* is widely distributed in Central and East Africa; it is found in DR Congo, Rwanda, Burundi, Sudan, Kenya, Uganda and Tanzania.

Uses Young leaves and shoots of *Acalypha bipartita* are eaten as a vegetable. They have a bland or slightly bitter taste and are chopped and added to cooking beans or peas and the mixture is served with a staple food. *Acalypha bipartita* is also useful as fodder and its stems are used to make baskets for winnowing and in construction of granaries. Several *Acalypha* species (e.g. *Acalypha indica* L.) are used in local medicine for a variety of complaints, but no medicinal uses have been reported for *Acalypha bipartita*.

Properties No data on composition are available for *Acalypha bipartita*, but shoots of *Acalypha indica* contain per 100 g edible portion: water 80 g, energy 269 kJ (64 kcal), protein 6.7 g, fat 1.4 g, carbohydrate 6 g, fibre 2.3 g, Ca 667 mg, P 99 mg, Fe 17 mg and ascorbic acid 147 mg (Siregar, 2001).

Botany Monoecious, scrambling subshrub, up to 3 m tall, with subquadrangular, sparsely to densely pubescent, green to red-brown stems. Leaves alternate, simple; stipules subulate, up to 4 mm long; petiole up to 7 cm long; blade ovate to elliptical-ovate, 3–11 cm × 1–8 cm, base rounded and 5-veined, apex acuminate to rounded, margins serrate, sparingly pubescent, lateral veins 4–6 pairs. Inflorescence spicate or subracemose, axillary, solitary, up to 14 cm long, bracteate, with a terminal male portion and 1–2 female units below the male portion. Flowers unisexual, sessile, without petals; male flowers green-white, calyx 4-partite, stamens 8; female flowers enclosed by large, folded, dentate bracts 1–1.5 cm in diameter, sepals 3, triangular-ovate, ovary superior, 3-celled, globose to 3-lobed, styles 3, free, 3–6 mm long. Fruit a 3-lobed capsule c. 2.5 mm × 3.5 mm, smooth, pubescent, 3-seeded. Seeds subglobose, 1.5–2 mm in diameter, grey-brown.
Acalypha is a large genus comprising about 450 species, occurring mainly in the tropics but extending to warm temperate areas. Tropical Africa and Asia have about 25 species each, tropical America about 400. The following species are used as a vegetable in the same way as *Acalypha bipartita*: *Acalypha ciliata* Forssk. in Benin and Nigeria, *Acalypha fruticosa* Forssk. in Tanzania, *Acalypha indica* L. in India and Indonesia, *Acalypha ornata* Hochst. ex A.Rich. in Tanzania and *Acalypha segetalis* Müll.Arg. in Nigeria. However, the medicinal uses of these species are more important, except for

the latter.

Ecology *Acalypha bipartita* grows in forest undergrowth and forest edges, extending into wooded grassland mainly in disturbed localities, at 1000–1500 m altitude. It prefers sandy loams, but grows on a wide range of soils, usually in areas with an annual rainfall of 900–1500 mm. It can be an invasive weed in grazing areas.

Management *Acalypha bipartita* is collected from the wild, usually in the rainy season but in riverine locations all year round.

Genetic resources and breeding *Acalypha bipartita* is common in its distribution area and not in danger of genetic erosion.

Prospects *Acalypha bipartita* is without large commercial possibilities, but the use as a leafy vegetable and fibre plant will remain of local importance.

Major references Katende, A.B., Ssegawa, P. & Birnie, A., 1999; Radcliffe-Smith, A., 1987; Ruffo, C.K., Birnie, A. & Tengnäs, B., 2002.

Other references Siregar, A.H., 2001; Burkill, H.M., 1994; Gilbert, M.G., 1995; Gilbert, M.G., Holmes, S. & Thulin, M., 1993; Keay, R.W.J., 1958b; Léonard, J., 1962; Radcliffe-Smith, A., 1996.

Authors P.C.M. Jansen

ACANTHOPHOENIX RUBRA (Bory) H.Wendl.

Protologue Fl. Serres Jard. Eur. 16: 181 (1867).

Family Arecaceae (Palmae)

Synonyms *Areca rubra* Bory (1804), *Acanthophoenix crinita* (Bory) H.Wendl. (1867).

Vernacular names Barbel palm, red palm, Mascarene Islands cabbage palm (En). Palmiste rouge, palmiste bourre, palmiste des bois, palmiste des hauts, palmiste épineux, palmiste zépines, palmiste piquant (Fr).

Origin and geographic distribution *Acanthophoenix rubra* is endemic to Réunion, Mauritius and Rodrigues.

Uses The palm heart (palm cabbage) is edible and much appreciated in Réunion and Mauritius as a delicacy. A decoction of the roots is used as a diuretic. *Acanthophoenix rubra* is cultivated as an ornamental, also outside its natural range.

Properties The palm heart of *Acanthophoenix rubra* is very susceptible to enzymatic browning, caused by polyphenol oxidases, especially catecholases.

Botany Palm with solitary trunk up to 12 m tall and up to 18 cm in diameter, sometimes enlarged at base. Leaves c. 10 in crown, arranged spirally, up to 3 m long, pinnately compound; sheath 30–60 cm long, red turning brown at maturity, with numerous spines up to 11 cm long and shedding at maturity; petiole up to 30 cm long, often spiny; leaflets in 25–65 pairs, up to 105 cm × 4 cm, with bristles on midrib above. Inflorescence below the leaves, up to 50 cm long, peduncle short, branches long and pendulous, unarmed or with dark-brown spines up to 15 cm long. Flowers unisexual, 3-merous, white or cream-coloured, arranged in triads of 2 male flowers and 1 female flower; male flowers with imbricate sepals c. 2 mm long, valvate petals up to 8 mm long and (4–)6–12 stamens; female flowers with imbricate sepals c. 3 mm long, imbricate petals up to 5 mm long, 6–9 small staminodes and superior, 1-celled ovary. Fruit an ellipsoid to globose drupe up to 1 cm long, 1-seeded. Seed globose, c. 7 mm in diameter, brown; endosperm homogeneous.

Acanthophoenix comprises a single but variable species.

Ecology *Acanthophoenix rubra* occurs in the upland mixed moist forest and heath sites of Mauritius above 500 m altitude. In Réunion it grows at 500–1500 m altitude. It is reported to tolerate light frost.

Management *Acanthophoenix rubra* is propagated by seed. It is cultivated both in Réunion and Mauritius for its palm heart and as an ornamental. It is quite easy to grow, but should be protected from full sunlight when young. Weed control is essential in the early stages of development. Fairly large amounts of organic matter in the soil stimulate growth. *Acanthophoenix rubra* has been tested in on-farm diversification programmes in the north-eastern highlands of Réunion.

Genetic resources and breeding Wild *Acanthophoenix rubra* was common in the past, but has become rare in Mauritius due to uncontrolled collection of palm heart. In Réunion it also became rare because of the establishment of sugarcane plantations and palm heart collection. The total natural population is estimated at about 1300 palms. Only about 100 reproductive individuals are present in Mauritius, and most of them are quite isolated. Natural regeneration seems poor. Introduced animals, e.g. rats, snails (*Achatina* spp.) and domestic pigs, are predators of the fruits and seedlings. *Acanthophoenix rubra* is listed as critically endangered on the IUCN Red List. A

large population has been located on Rodrigues and founder palms for a restoration programme are being identified. Barbel palm is common in cultivation as an ornamental in Mauritius and Réunion and is occasionally grown elsewhere.

Prospects Palm heart production on a commercial scale is an option if the plantations can be protected effectively until the commercially interesting age. The single stem habit, however, is a major drawback. Other palms are being tested on an experimental scale in Réunion as possible replacements for *Acanthophoenix rubra*: *Euterpe oleracea* Mart. (assai palm) and *Bactris gasipaes* Kunth (pejibaye or peach palm), both with higher growth rates and with the great advantage of being palms with clustering stems. *Acanthophoenix rubra* is an attractive ornamental palm, with its dark red spiny leaf bases. It is quite rare in international trade and a real collector's item. Seed collection should be restricted to cultivated plants.

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Other references IUCN, 2002; Kew Conservation Staff, 1996; Palmarium, 2003; Robert, C., Rouch, C. & Cadet, F., 1997; Tuley, P., 1995; Uhl, N.W. & Dransfield, J., 1987.

Authors W.J. van der Burg

ACANTHOSICYOS HORRIDUS Welw. ex Hook.f.

Protologue Benth. & Hook.f., Gen. pl. 1(3): 824 (1867).

Family Cucurbitaceae

Vernacular names Nara, nara bush, nara melon (En). Nara, melon nara (Fr). Nara (Po).

Origin and geographic distribution *Acanthosicyos horridus* is endemic to the Namib Desert of the south-west coast of Africa and occurs from southern Angola, through Namibia to South Africa (north-western Namaqualand). The distribution of nara is limited to the coastal part of the Namib Desert where it grows exclusively in the sand dunes of mostly dry river beds where subsurface water is available. Before the introduction of maize into southern Africa, nara was a traditional staple food. Archeological evidence indicates that it has been a staple food for at least 8000 years, and was transported and perhaps even traded that long ago. It has not been domesticated and

Acanthosicyos horridus – wild

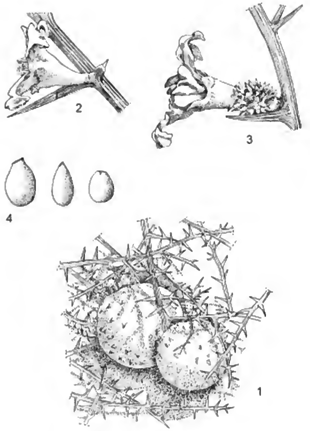
attempts to introduce it elsewhere have not been successful.

Uses The seeds of nara, known as butternuts or butterpips, are eaten either fresh or roasted as a snack food, or ground into flour for cooking with other dishes. They are a good substitute for almonds, and have been exported to bakeries in Cape Town for use in confectionery. In Namibia ripe fruits, which are sweet and juicy and about 900 g in weight, are either eaten raw and relished for their high water content, or made into a traditional preserve, the dried fruit pulp being made into flat cakes. Nara is also eaten as a famine food.
Young stem tips are browsed by livestock. The bitter roots have medicinal value. Either chewed or made into a decoction, they are used to treat nausea, stomach-ache, venereal diseases, kidney problems, arteriosclerosis and chest pains. The crushed root mixed with fat is used to heal wounds. Oil from the raw or boiled seeds is used as a skin moisturizer and to protect the skin from sunburn.

Production and international trade There is no commercial production of nara fruits. Trade in seeds between Namibia and South Africa has been reported, but no statistics are available.

Properties The composition of the seeds per 100 g edible portion is: water 5.3 g, energy 2709 kJ (647 kcal), protein 30.7 g, fat 57.0 g, carbohydrate 2.3 g, crude fibre 1.3 g, Ca 100 mg, Mg 363 mg , Fe 4.0 mg, Zn 5.5 mg, niacin 2.2 mg. The composition of fresh fruits per 100 g edible portion is: water 84 g, energy 231 kJ (55 kcal), protein 1.4 g, fat 0.3 g, carbohydrate 11.7 g, fibre 1.0 g, Ca 21.4 mg, Mg 19.0 mg, P

22.4 mg, Fe 0.5 mg, Zn 0.6 mg, carotene 0.12 mg, thiamin 0.01 mg, riboflavin 0.02 mg, niacin 0.75 mg (Van den Eynden, V., Vernemmen, P. & Van Damme, P., 1992). The ripe fruits are aromatic and the pulp is rich in sugars. The fruit pulp and plant sap contain a non-volatile enzyme which curdles milk. A high percentage of the seed-oil is made up of polyunsaturated fatty acids, with a linoleic acid content of 53%. Green unripe fruits contain varying amounts of highly oxygenated tetracyclic triterpenoids, called cucurbitacins. Cucurbitacins B and D have been identified as the primary source of bitterness, together with traces of cucurbitacins G and H. These compounds cause a burning sensation in the mouth. As the fruits ripen they rapidly lose their bitterness under the influence of the enzyme elaterase. The same four cucurbitacins are found in higher concentrations in the dried root. The bitter principles occur as aglycones in the fruits, but as glycosides in the roots. The LD_{50} of cucurbitacin B administered intraperitoneally to mice is 1 mg/kg, and this dose produces pulmonary oedema. The fruit juice contains germination



Acanthosicyos horridus – 1, habit of fruiting plant; 2, male flower; 3, female flower; 4, seeds. Redrawn and adapted by Iskak Syamsudin

inhibitors, which act to a large extent by an osmotic stress factor. The starches are of an unusually small size, which renders them suitable in the production of biodegradable plastics.

Description Perennial, dioecious, strongly branched shrub up to 1 m tall and 15(–40) m in diameter, with a very long, woody taproot; stem longitudinally grooved, pale yellowish to pale green, spiny; spines in pairs, 2–3 cm long. Leaves reduced to minute scales, apparently absent. Flowers unisexual, regular, 5-merous, sessile or shortly stalked in spine axils; calyx campanulate, with ovate lobes, greyish hairy; corolla deeply lobed, lobes broadly ovate, c. 1 cm long, fleshy, pale yellow or pale green; male flowers solitary or fasciculate, with 3–5 stamens; female flowers solitary, with 5 elongate staminodes and inferior, ovoid ovary densely covered with oblong-conical, 2–2.5 mm long, soft spines, style columnar, with 3–5 two-horned flat or capitate stigmas. Fruit a subglobose berry up to 20 cm in diameter, covered with spiny protuberances, ripening from green to pale yellow or pale orange-yellow, many-seeded. Seeds embedded in yellow to orange-yellow pulp, oblong or ovoid, 12–16 mm × 7–11 mm × 5–7 mm, cream-coloured, hard with a thick testa.

Other botanical information *Acanthosicyos* comprises 2 species and is placed in the tribe *Benincaseae*, together with important genera including *Benincasa*, *Citrullus*, *Coccinea*, *Lagenaria* and *Praecitrullus*. *Acanthosicyos naudinianus* (Sond.) C.Jeffrey differs notably from *Acanthosicyos horridus* in its creeping, annual, leafy stems.

Growth and development Nara is able to survive in a hyper-arid desert climate because of its woody taproot that grows deep into the sand allowing it to reach subterranean water. It can survive in years without any rainfall and in some areas it is the only plant species found. A single nara shrub can cover an area of up to 1500 m^2. Nearly 40% of the plant's above-ground biomass is made up of spines, the rest of stems. In the absence of leaves, photosynthesis takes place in these spines and stems. The dense lattice-like growth of older stems serves to catch and bind windblown sand, acting as a dune stabilizer and thus the plant builds up its own dune micro-ecosystem. Male plants produce more flowers than the female ones and may flower nearly all year long, with a decline in flower production during early winter (May–July). Female plants flower from

August–April, and their fruits mature from December–May. Having sticky pollen, nara is probably pollinated by insects. Germination has been reported by local inhabitants to occur only after rain. The age of mature fruiting nara plants may exceed 100 years.

Ecology The coastal Namib Desert where nara is found receives extremely low and variable amounts of rainfall, the annual average not exceeding 100 mm, and in some years there is no rain at all. Precipitation is augmented by the frequent occurrence of fog. The distribution of nara roughly approximates the inland limits of the fog belt. Temperatures along the coast are fairly constant, the minimum averaging 16°C and the maximum 21°C. Due to the constantly shifting dunes, soil formation does not occur, thus presenting a nutrient-poor plant environment. The mineral composition of the dune sands is quartz, feldspar and garnet. Sands underneath nara plants are exceptionally low in nitrogen and phosphorus content. Other plants sometimes found growing in association with nara are the dune grass *Stipagrostis sabulicola* (Pilg.) De Winter, and the leaf succulent *Trianthema hereroensis* Schinz. Nara plays an important ecological role in the Namib Desert, providing shelter, food and water for many species of invertebrates, reptiles, mammals and birds, some of which are endemic and depend entirely on nara for their survival.

Propagation and planting The 1000-seed weight of nara is about 300 g. Seeds germinate easily, but plants seldom flourish in cultivation.

Management Nara fruits are collected from wild plant populations. They are neither cultivated nor domesticated. Attempts to domesticate the nara bush have been unsuccessful for reasons relating to its very specific habitat requirements. Each family of the Topnaar people of the Lower Kuiseb Valley near Walvis Bay, Namibia owns a number of nara bushes, which are considered private property, but not including the land they grow on. Harvesting is only allowed from the plants owned by the family concerned.

Harvesting At the time nara fruits begin to ripen (from December onwards) many Topnaar families move to the nara fields to harvest and process the fruits. The harvesting can last until May.

Handling after harvest The Topnaar people process the nara fruits into a preserve. Ripe fruits are collected and either buried in the soil or left in the sun for softening, after which they are peeled and then boiled until the seeds become loose. The pulp is allowed to thicken and turns into a dark orange colour. After separating the seeds, the thick remaining pulp is poured out and allowed to dry in the sun. It solidifies in a few days, forming flat leathery cakes, called 'goa-garibeb', which are then cut into strips or rolled up for storage. These fruity rolls have good keeping quality and can be chewed or added to porridge for the remainder of the year. The seeds are sieved from the boiled fruit flesh, dried in the sun and stored for eating, grinding into a flour, or sale to traders. Raw seeds are separated from the fruit pulp by rubbing them in the sand.

Genetic resources Over the past 20 years there has been a reduction of possibly as much as one third in the size of the nara populations being harvested by the Topnaar along the Kuiseb River. The construction of a flood-retaining dam coupled with dune encroachment has stopped the flow of surface water. However, there are uninhabited areas along the coastal Namib Desert where nara still occurs abundantly. Germplasm of *Acanthosicyos horridus* is held at the National Plant Genetic Resources Centre, Windhoek, Namibia.

Prospects Although today nara does not play as intrinsic a role in the lives of the Topnaar people as it did before, it remains an important part of their tradition and culture. Its protection should be a high priority to ensure human survival in the Namib Desert and for combating desert encroachment. Research is being undertaken in Namibia on the germination and possible cultivation of *Acanthosicyos horridus* to explore its cost-effectiveness as a crop. Namibian scientists are currently working with the Topnaar to sustain and improve the existing nara fields. There may be further potential in the seed trade, and marketing skills and techniques could enable the Topnaar to see a better income from the sale of nara seeds.

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Sources of illustration Sandelowsky, B.H., 1990.

Authors M.H. Wilkins-Ellert

ACANTHOSICYOS NAUDINIANUS (Sond.) C.Jeffrey

Protologue Kew Bull. 15(3): 346 (1962).

Family Cucurbitaceae

Chromosome number n = 11

Synonyms *Cucumis naudinianus* Sond. (1862), *Citrullus naudinianus* (Sond.) Hook.f. (1871), *Colocynthis naudianus* (Sond.) Kuntze (1891).

Vernacular names Herero cucumber, gemsbok cucumber, wild melon (En).

Origin and geographic distribution *Acanthosicyos naudinianus* is native to Zambia, Angola, Namibia, Botswana, Zimbabwe, Mozambique and South Africa.

Uses The mature fruits of *Acanthosicyos naudinianus* are eaten raw or roasted; unripe fruits cause a burning sensation of the tongue and lips when eaten raw. The fruit also provides an important source of water. The fruit skin and the seeds are roasted and pounded to make a meal. The tuberous roots are considered inedible or even poisonous and in Zambia they have been reportedly used for homicidal purposes. The preparation and use of arrow poison made from the roots of *Acanthosicyos naudinianus* is widespread among bushmen tribes in Angola, Namibia and Botswana.

Properties Some *Acanthosicyos naudinianus* plants produce bitter fruits. The bitter taste is attributed to cucurbitacin B (c. 0.001%). Fruits contain per 100 g:: water 90.6 g, energy 111 kJ (27 kcal), protein 1.3 g, fat 0.2 g, carbohydrate 4.8 g, fibre 2.1 g, Ca 21 mg, Mg 23 mg, P 25 mg, Fe 0.5 mg, thiamin 0.09 mg, riboflavin 0.03 mg, niacin 0.98 mg and ascorbic acid 35 mg (Arnold, T.H., Wells, M.J. & Wehmeyer, A.S., 1985). The seed kernel yields c. 15% thin, yellow non-drying oil, and the residue contains c. 20% protein. In the older roots the total content of cucurbitacins amounts to 1.4%. Cucurbitacins, which are also known from other *Cucurbitaceae* and various other plant species, exhibit cytotoxicity (including antitumour activity) and anti-inflammatory and analgesic activities.

Botany Perennial, dioecious, scandent herb with solitary, spiniform tendrils; root tuberous, up to 1 m long; stem annual, up to 6 m long, rooting at the nodes, glabrescent. Leaves alternate, simple; stipules absent; petiole 0.7–7.5 cm long; blade ovate to broadly ovate in outline, usually deeply palmately 5-lobed, 3–18 cm × 2.5–14 cm. Flowers solitary, unisexual, 5-merous; petals yellow to white, 1.4–2.5 cm × 0.9–1.3 cm; male flowers with pedicel up to 2 cm long, receptacle campanulate, up to 6 mm long, pale green, sepals up to 6 mm × 1.5 mm, stamens 3 or 5; female flowers with pedicel up to 8 cm long, receptacle cylindrical, 3 mm long, sepals 3–4 mm long, 3 small staminodes, ovary inferior, spiny. Fruit an ellipsoid or subglobose berry 6–12 cm × 4–8 cm, weight c. 250 g, fleshy, covered with seta-tipped fleshy spines, many-seeded. Seeds ellipsoid, slightly compressed, 7.5–10 mm × 4–6 mm.

Acanthosicyos comprises 2 species and is placed in the tribe *Benincaseae* together with important genera such as *Benincasa*, *Coccinia*, *Citrullus*, *Lagenaria* and *Praecitrullus*. The better known nara melon (*Acanthosicyos horridus*) differs notably from *Acanthosicyos naudinianus* by its shrubby habit and leafless, spiny stems, and is restricted to Angola, Namibia and South Africa.

Elephants feed on the fruits and may play an important role in the dispersal of seeds.

Ecology *Acanthosicyos naudinianus* is a typical Kalahari species which prefers deep sandy soils. It occurs in woodland, wooded grassland and grassland at altitudes of 900–1350 m. It is not frost tolerant but tolerates a saline subsoil.

Management The fruits of *Acanthosicyos naudinianus* are exclusively collected from the wild.

Genetic resources and breeding There is no indication that *Acanthosicyos naudinianus* is threatened. As in many other cucurbits there is considerable variation in the bitterness of the fruits. This will allow for selection and breeding of more palatable lines. There are 4 documented accessions held in the United States and 2 at the Royal Botanic Gardens Kew (United Kingdom).

Prospects In view of increasing demands for edible oil and protein in arid lands, *Acanthosicyos naudinianus* is a candidate for development as a high-yielding, dry country crop. It yields a crop quickly, harvesting the fruits is easy, it has a wide ecological adaptation, it is

easily propagated and handled, and fruits store well. As such, it compares favourably with *Acanthosicyos horridus* as a candidate for domestication.

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Authors C.H. Bosch

ACMELLA OLERACEA (L.) R.K.Jansen

Protologue Syst. Bot. Monogr. 8: 65 (1985).

Family Asteraceae (Compositae)

Chromosome number $2n = 60, 78$

Synonyms *Spilanthes oleracea* L. (1767), *Spilanthes acmella* auct. non (L.) Murr.

Vernacular names Toothache plant, paracress (En). Brède mafane, cresson de Para (Fr). Agrião di Pará, jambú (Po).

Origin and geographic distribution *Acmella oleracea* is not known from the wild. It is thought to have been derived through cultivation from *Acmella alba* (L'Hér.) R.K.Jansen, a species native to Peru and Brazil. It must have been in cultivation for a considerable time and has spread throughout the tropics. It is locally cultivated throughout Africa and escapes from cultivation have been reported. In East Africa it has become naturalized. It was probably introduced in the Indian Ocean Islands by the Portuguese and subsequently spread in East Africa by Indian labourers who came to work on railroad construction around 1900.

Uses In the Indian Ocean islands (Comoros, Madagascar, Réunion, Mauritius) and India the main use of the leaves of *Acmella oleracea* is as a steamed vegetable. The raw leaves are used as a flavouring for salads, soups and meats in Brazil and India. It is grown widely as an ornamental because of the attractive colourful heads.
The most common and widespread medicinal use is to treat toothache and throat and gum infections. Worldwide the flower heads are used either fresh or dried and powdered, but the use of roots and leaves has been recommended as well. The plant is further recommended as a cure for dysentery and rheumatism, and to enhance the immune system. It is used against blood parasites, especially against malaria, both prophylactic and curative.

Properties Data on nutritional composition are not available. Raw *Acmella* leaves and flower heads have a pungent taste; they cause numbing of the mouth when chewed and induce the production of saliva. This sensation may be attributed to the alkylamide fraction.
The flower heads contain up to 1.25% of spilanthol (N-isobutyl-4,6-decadienamide), an antiseptic alkaloid. Spilanthol is effective at very low concentrations against blood parasites. It is a poison for most invertebrates, but is said to be harmless to warm-blooded animals. Different sources commenting on the composition of the essential oil distilled from fresh flowers agree on a high content of β-caryophyllene (21–30%). Other major constituents reported are limonene, thymol, γ-cadinene and germacrene.
In-vitro studies have shown strong antibacterial activity against *Escherichia*, *Klebsiella*, *Proteus*, *Pseudomonas*, *Salmonella* and *Staphylococcus*. Also *Candida albicans* is inhibited. Use as an insecticide has proved effetive against e.g. *Aedes*, *Anopheles* and *Culex* mosquitoes and corn earworm (*Helicoverpa zea*).

Botany Annual herb with erect stems, sometimes decumbent. Leaves opposite, simple; petiole 2–6.5 cm long; blade broadly ovate to deltate, 5–11 cm × 4–8 cm, base truncate to shortly attenuate, apex acute to shortly acuminate, margin dentate. Inflorescence a discoid head up to 2.5 cm × 1.5 cm; involucral bracts 15–18, 3-seriate, up to 8 mm × 1 mm, apex acute; receptacular bracts straw-coloured, often tinged purple-red, up to 6 mm × 1 mm. Disk flowers 400–620, corolla 5-merous, yellow, up to 3.5 mm long. Fruit an achene 2–2.5 mm × 1 mm; pappus consisting of 2 bristles.
Acmella is a pantropical genus of about 30 species, with 2 of these native to tropical Africa, and 2 introduced. Most *Acmella* species were formerly considered to belong to the genus *Spilanthes*. The 2 native species, *Acmella caulirhiza* Delile (synonym: *Spilanthes mauritianus* auct. non (Rich.) DC.) and *Acmella uliginosa* (Sw.) Cass., have similar uses as *Acmella oleracea* and have undoubtedly been mixed up in the literature. *Acmella caulirhiza* can be distinguished from *Acmella oleracea* by the presence of ray flowers. *Acmella uliginosa* has a 4-merous corolla.

Ecology As an escape from cultivation *Acmella oleracea* is found in weedy habitats. Naturalized populations are usually found in

wet localities such as lakeside marshes.

Management *Acmella oleracea* is grown as a vegetable in Madagascar and Comoros, and also in Réunion and Mauritius, but details have not been reported. It is sold in markets in Madagascar throughout the year with peak supplies from November–March. As an ornamental it is propagated by seed or by cuttings taken from plants in the vegetative phase. For germination a temperature of at least 21°C is needed. It needs frequent watering.

Genetic resources and breeding As *Acmella oleracea* is widely grown, and is naturalized in parts of East Africa, it is certainly not threatened.

Prospects It would be worthwhile documenting the cultivation practices, characteristics and properties of *Acmella oleracea* grown in the Indian Ocean islands. *Acmella oleracea* and its wild ancestor *Acmella alba* are interesting for further research on medicinal potential, especially concerning activity against blood parasites other than malaria. The research community should be made aware of the updated nomenclature in the genera *Acmella* and *Spilanthes* to avoid replication of research findings, doubtful identifications and the use of incorrect names.

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Authors C.H. Bosch

ADANSONIA DIGITATA L.

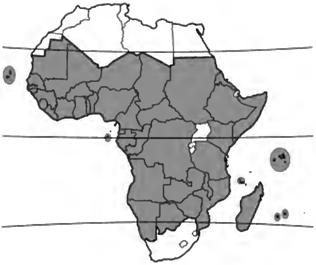
Protologue Syst. nat. ed. 10, 2: 1144 (1759).

Family Bombacaceae (APG: Malvaceae)

Chromosome number $2n = 160$

Vernacular names Baobab, monkey-bread tree, dead-rat tree, cream-of-tartar tree (En). Baobab, calebassier du Sénégal, arbre de mille ans (Fr). Baobab, molambeira, imbondeiro, calabaceira, cabacevre (Po). Mbuyu, mkuu hapingwa, mkuu hafungwa, muuyu (Sw).

Origin and geographic distribution Baobab occurs naturally in most of mainland tropical Africa. Originally it was absent from many Central African countries, but it has been introduced in most of them. In mainland tropical Africa it is still absent from Rwanda, Burundi,



Adansonia digitata – wild and planted

Djibouti and Uganda. It has been introduced in Madagascar and many other Indian Ocean islands. In West Africa it often occurs in baobab orchards around villages. Outside Africa it has been widely introduced in tropical and subtropical regions. In India it is a fairly old introduction most likely brought by Arab traders and it now has many local uses similar to those in Africa. In Barbados two old trees, grown from seed imported in 1738 from West Africa, are considered one of the seven wonders of the island.

Uses The leaves of baobab are used either fresh as a cooked vegetable or dried and powdered as an ingredient of soups and sauces. The shoots and roots of seedlings are eaten as well. The roots are boiled and eaten in West Africa in times of famine. The flowers are eaten raw.

The fruit contains soft, white, edible and nutritious flesh ('monkey bread'). It is used to curdle milk, it is eaten as a sweet and is used in making gruel and refreshing drinks and ice-cream. In Sudan it is made into a milk-like drink called 'gubdi'. The powdered fruit flesh is added to cold liquid, thus preserving vitamins. An emulsion of the fruit pulp may be used to adulterate milk. The dried pulp is used as a substitute for cream of tartar in baking.

The seeds are eaten raw or roasted and are used to thicken and flavour soup. Fermentation of the seed kernels improves the nutritional value. In coastal Kenya and Tanzania the pulp-coated seeds are coloured and sugar-coated and sold as sweets. The seeds are used to adulterate groundnuts and may be used as a coffee substitute. An oil can be extracted from the

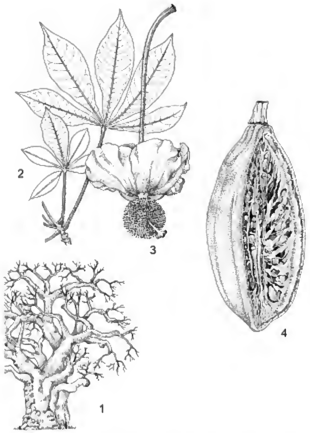
seed kernels by boiling and distillation. It is semi-fluid, golden yellow, gently scented, non-drying and has a long shelf life. It is used for cooking and in the cosmetics industry.
The bark fibre is stripped from the lower part of the trunk and is used to make rope, string, cords for musical instruments, snares, fishing-nets, loin cloths, sacking, baskets, mats and waterproof hats. The root bark yields a fibre as well. When the wood disintegrates fibres remain that may be used as packing material.
All plant parts are used for treating fever. The bark gum is used for cleaning sores. A decoction of the bark is used in Congo to bathe rickety children and in Tanzania to treat toothache. Stem bark and fibres lining the fruit husk are used to treat amenorrhoea. The bark, fruit pulp and seeds are used as an antidote for *Strophanthus* poisoning. In Malawi baobab juice called 'dambedza' is served as a cure for hangovers and against constipation. In Zambia a root infusion is used to bathe babies to promote a smooth skin. A root decoction is taken with food in Sierra Leone for strength. Dried powdered roots are included in the treatment of malaria. Leaves are used as a diaphoretic, expectorant, astringent and as a fever prophylactic. Leaves are found in a long list of treatments for ailments including asthma, fatigue, kidney and bladder diseases, diarrhoea and inflammations. Fruit pulp is used as an anti-dysenteric and in the treatment of smallpox and measles. The seed oil is used for inflamed gums and to ease toothache.
The leaves and fallen flowers are eaten by livestock, and fruit pulp and seeds are fed during the dry season. Residues of oil extraction are fed to livestock as well.
The wood is used locally for canoes, wooden platters and floats for fishing nets. It makes poor firewood and charcoal. Use of the wood and bark for the paper industry is possible but not commercially viable. The fruit husks are used as fuel and are made into containers and fishing floats.
Trees with hollow trunks have been used for a long time and are still used for water storage, having capacities of up to 7500 l. Hollow trees are also used as tombs, meeting places, prisons, stables, bus shelters, storage rooms, watchtowers, bathrooms, cool rooms and dairies. Pulp is used for smoking fish and the smoke is helpful in repelling insects that pester livestock. The pollen mixed with water gives a glue that is used in carpentry. The bark is used for tanning and green bark yields a dye. A red dye is obtained from the roots. The powdered peduncle and the husk of the fruit are used as a substitute for tobacco. Introductions outside its native range were made mainly for use as an ornamental or shade tree. The extraordinarily shaped baobab tree is surrounded by a wealth of legends, superstitions, folktales and anecdotal references throughout Africa.

Production and international trade The bark has been imported in the past into Europe by the packing and paper industry and for medicinal use. Under the name 'cortex cael cedra' it was used as a substitute for quinine to reduce fevers. Recently in the Western world, commercial interest has grown for applications in the health food and cosmetics industries. In Zimbabwe small-scale industrial production of fruit pulp and oil takes place. In Malawi fruit juice of baobab is produced commercially. Seeds are exported from East Africa to the Arab world and the Middle East for use as snacks. No statistics are available on production or trade.

Properties The nutritional composition of fresh baobab leaves per 100 g edible portion is: water 77 g, energy 289 kJ (69 kcal), protein 3.8 g, fat 0.3 g, carbohydrate 16.1 g, fibre 2.8 g, Ca 402 mg, P 65 mg, ascorbic acid 52 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968).
The fruit pulp of baobab contains per 100 g: water 8.7 g, energy 1290 kJ (308 kcal), protein 2.7 g, fat 0.2 g, carbohydrate 73.7 g, fibre 8.9 g, Ca 335 mg, Mg 167 mg, P 76.2 mg, Fe 2.7 mg, Zn 1.0 mg, thiamin 0.62 mg, riboflavin 0.14 mg, niacin 2.7 mg, ascorbic acid 209 mg. The seed consists of about 55% seed coat and 45% kernel. The seed kernels contain per 100 g: water 8.1 g, energy 1805 kJ (431 kcal), protein 33.7 g, fat 30.6 g, carbohydrate 4.8 g, fibre 16.9 g, Ca 273 mg, Mg 640 mg, P 5.1 mg, Fe 6.6 mg, Zn 6.7 mg, thiamin 0.25 mg, riboflavin 0.14 mg, niacin 1.0 mg. The fatty acid composition is linoleic acid 34.9%, oleic acid 32.3%, palmitic acid 26.5% and stearic acid 4.4% (Arnold, T.H., Wells, M.J. & Wehmeijer, A.S., 1985). The reported range of oil content of seed kernels is wide: 30–68%.
Nutritional properties reported in the literature vary considerably but a relation between morphology or origin and properties is not evident. In Mali the ascorbic acid content of leaves varied 3-fold between trees; this was consistent over years, and correlations with rainfall or morphological types were not found. However, small leaves, a tree-specific characteristic, had an approximately 20% higher vitamin A con-

tent, whereas the age of the tree did not have an effect on the vitamin A content of the leaves. The highest value for vitamin A in sun-dried leaf powder was 27.2 μg/g.
The air-dry wood is light with a specific gravity of about 210 kg/m³. The fibres from the inner bark are soft, durable, moderately strong and 90–120 cm long.
All plant parts contain mucilage, rich in uronic acid. The bark gum is odourless, tasteless, insoluble and contains betulinic acid. The bark has been shown to have diaphoretic and antiperiodic activities. Adansonin, isolated from the bark, has been found to have febrifugal properties. This compound is also thought to be the active principle that neutralizes strophantin, but other evidence indicates that adansonin itself causes *Strophanthus*-like poisoning. The leaves have hyposensitive and antihistamine activities. Root bark and leaf extracts have antiviral and antibacterial activities. The seed kernel contains a trypsin inhibitor, which can be reduced by 85% by alkali treatment. The tannin content of the leaves (12% of dry matter) has a marked negative effect on their digestibility by livestock.

Description Massive deciduous tree, up to 20(–23) m tall, trunk often of vast girth; bark smooth, variable in colour; branches stout near the trunk, young branches often tomentose; root system extending up to 2 m deep and horizontally further than the height of the tree. Leaves alternate, simple (in young trees and first leaves of the season in old trees) or digitately compound, at the apex of branches; stipules early caducous; petiole up to 16 cm long; compound leaves 5–7(–9)-foliolate, c. 20 cm in diameter; leaflets sessile or shortly stalked, elliptical, 5–15 cm × 1.5–7 cm, base cuneate, apex acuminate, mucronate, entire. Flowers solitary or paired, axillary, pendulous, bisexual; pedicel up to 90 cm long, tomentose; bracteoles 2, early caducous; calyx 3–5-lobed, 5–9 cm × 3–7 cm, shortly tomentose outside, velvety pubescent inside; petals 5, overlapping, very broadly obovate to oblate, 5–10 cm × 4.5–12 cm, base shortly clawed, apex rounded, white; stamens very numerous, united at base into a staminal tube 1.5–4.5 cm long, free part equally long, reflexed; ovary superior, 5–10-celled, style exserted c. 1.5 cm beyond anthers, stigma 5–10-lobed. Fruit a woody, indehiscent capsule, globose to ovoid or oblong-cylindrical, up to 40(–55) cm long, covered by velvety tomentum, filled with dry, mealy pulp, many-seeded. Seeds reniform, c. 1.5 cm × 1 cm, smooth, dark brown to black, with thick seedcoat. Seedling with hypogeal germination; cotyledons breaking free from testa; first leaves simple, narrowly linear; taproot swollen.



Adansonia digitata – *1, tree habit; 2, tip of leafy shoot; 3, flower; 4, opened fruit.*
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Adansonia* comprises 8 species, one of which is of African mainland origin, one endemic to Australia and 6 to Madagascar.
In the Sahel 4 types of baobab are distinguished: 'black-bark', 'red-bark', 'grey-bark' and 'dark-leaf'. The 'dark-leaf' type is preferred for use as a leaf vegetable, the 'grey-bark' type is used for fibre, and the others are preferred for the fruits. In Sudan size, shape and taste of the fruits differ between areas. In Kenya 3 types are distinguished, based on sweetness of the fruit, shape of the tree, size and shape of the fruit, and season of flowering. Distinguishing botanical varieties is tempting, but as variation is poorly understood so far, such a formal classification would be premature.
Chromosome numbers reported for *Adansonia digitata* are 96, 128, 144 and 160. Inaccurate counts are common in the *Bombacaceae* be-

cause the chromosomes are small and numerous. Baobab is now considered an autotetraploid that has undergone aneuploid reduction from $4x = 176$ to $2n = 160$. The other *Adansonia* species all have $2n = 88$.

Growth and development A growth model with 4 distinct growth phases has been developed based on data from South African trees. The first 'sapling' phase lasts 10–15 years at the end of which the diameter at breast height is 7–25 cm, height 3–6 m and crown width 2–4 m. The second or 'conical' phase lasts till the tree is 60–70 years old. In this phase growth is fastest and the stem attains its greatest height. At the end of the conical phase the trunk diameter is 0.8–2.2 m, height is 5–15 m and crown width 8–20 m. In the third or 'bottle' phase the trunk thickens and the crown widens with long ascending branches. This phase ends when the tree is 200–300 years old with trunk diameter of 2.8–5.5 m, height 10–20 m and crown width 15–35 m. In the last or 'old age' phase the trunk further expands, heavy branches droop and lower branches may break off from time to time. The crown becomes wide and flattens, the trunk becomes hollow and the tree ultimately dies at an age of 500–800(–1000) years. In exceptional growing conditions and through secondary growth some trees may become considerably older. In warmer areas the phases tend to be shorter. Seed-propagated trees in West Africa have reached a height of up to 2 m in 2 years and 12 m in 15 years.

Leaves appear shortly after the first rains, with early leaves often simple and soon falling. Flowering takes place at any time of the year except during the height of the dry season; it often precedes the appearance of the leaves. Flowers open late in the afternoon and remain open throughout the night with 1–50 flowers per tree. Flowering of a tree may last 6 weeks. First flowering has been observed on an 8-year-old tree. Grafted trees start flowering after only 3 years and do not become as tall as sown trees. Pollination is mainly by fruit bats, and to a lesser extent by bushbabies (lemurs) and possibly by wind, flies and moths. Pollinators are attracted by the strong carrion smell of the flowers. Animals, notably baboons and elephants, play a role in the dispersal of seed and in breaking its dormancy. Baobab regenerates new bark after the bark has been stripped. The exposed trunk of felled trees can be covered by bark and produce a new shoot from the centre of the stump as well as peripheral shoots.

Ecology Baobab prefers sandy topsoil overlying a loamy subsoil; it tolerates poorly drained soils with heavy texture, but is absent on deep sand. It is at its best at altitudes of 450–600 m with an annual rainfall of 300–500 mm; it is common in areas with an annual rainfall of 200–800 mm, and extremes in annual rainfall of 90 mm and 1500 mm have been recorded. It is found from sea-level to 1000(–1500) m altitude. Severe frost will kill even mature trees and in the southern part of its area of distribution it is found mostly on north facing slopes, sheltered from cold southern winds. Seedlings and small trees are vulnerable to fire, but mature trees are fire resistant.

Propagation and planting Natural regeneration of baobab is poor, mainly because of browsing animals and uncontrolled bush fires. Unaided germination of baobab seeds is generally poor. Seeds that float in water should be discarded. Pre-treatment of seeds can be done by cracking, immersing in boiling water for 5–7 minutes or in sulphuric acid for 6–12 hours, and should lead to a germination rate of 80–95%. Sowing in bags is done 4–6 months before the expected start of the rainy season. Farmers sometimes care for baobab seedlings in their courtyard until they are 2–3 m tall, when they are transplanted along the borders of their fields. Vegetative propagation has the advantage that desirable characteristics like large leaves and good quality can be assured. Stem cuttings can be easily rooted in nurseries. For grafting 3-month-old seedlings can be used with fresh scions.

Plants are transplanted at the start of the rainy season. After transplanting in the field, protection against game, livestock and fire are essential until the trees are well established. Planting is done at a spacing of about 10 m × 10 m.

Management Pollarding encourages leaf production and it helps to prevent toppling of hollow trees, but fruit production will be severely reduced for several years.

Diseases and pests The insect life associated with baobab has been well investigated as baobab is a potential alternative host for cotton and cocoa pests and diseases. A wide range of cotton bollworms, cotton stainer bugs, flea beetles and mealy bugs have been recorded. Eradicating baobab as a crop protection measure has failed, as numerous other alternative hosts exist. Girdling of stems of young trees by beetles can kill them. A condition called 'sooty mould' discolours the bark especially in dry periods; it is a secondary fungal infection re-

sulting from stress. In southern Africa the mopane worm (*Gonimbrasia belina*), considered a delicacy, feeds on the leaves. Bark-eating elephants are the most important threat to older baobab trees.

Harvesting Harvesting leaves and fruits is done by climbing the tree. Fruits may also be shaken off from the branches. The bark is removed by stripping after horizontal and vertical cuts have been made. Bark regrows and can be harvested again after several years.

Yield No data are available on leaf or fibre yields. An average mature tree produces about 200 kg of fruit per year.

Handling after harvest Drying of baobab leaves in the shade results in smaller losses of vitamin A than drying in the sun. Fruit pulp is sun dried or fermented. A machine has been developed for the mechanical separation of the fruit pulp from the rest of the fruit. Traditionally seeds and pulp are sun dried, roasted or fermented. Pulp can be stored for long periods in airtight containers. The seed-coats and kernels can be separated by hand after boiling (1 hour) and soaking (12 hours).

Genetic resources The variation in size between trees of identical age is usually attributed to site differences. However, the considerable size differences between baobab trees of identical age and at the same location suggest that the variation is mainly of genetic origin. In view of the variation in the species, sampling throughout its range of distribution is required to establish a representative germplasm collection. For the species as a whole there seem to be no threats of extinction or genetic erosion although locally (e.g. in eastern Zimbabwe) populations are under threat due to changes in the hydrology or to overexploitation.

Breeding In view of the large variation in baobab, breeding and selection offer great opportunities.

Prospects As a local source of leafy vegetable, fruit, fibre and other products baobab will continue to play an important role. Extension, notably on processing, could promote more intensive production and use. Local and international markets are likely to be able to absorb considerable quantities of produce. In view of the long productive life of baobab it is worthwhile planting only the best seedlings. Screening of seedlings for fast growth may be a tool to increase production. Research to understand the large variation in baobab should lay the foundation for future breeding programmes. Extensive provenance testing is required. As in other tree crops, breeding will be a long-term undertaking. In the short term the best strategy will be vegetative multiplication of superior trees.

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ALEPIDEA PEDUNCULARIS Steud. ex A.Rich.

Protologue Tent. fl. abyss. 1: 320 (1848).

Family Apiaceae (Umbelliferae)

Synonyms *Alepidea longifolia* Dummer (1913).

Origin and geographic distribution *Alepidea peduncularis* occurs from DR Congo, Sudan and Ethiopia south to South Africa.

Uses Young leaves of *Alepidea peduncularis* are collected from the wild and used as a cooked vegetable, particularly in southern Africa, where it is known as 'ikhokwana' by the Zulu people. In southern Africa a decoction of the roots is taken to treat cough and in eastern Africa as a cure for fever.

Botany Perennial herb up to 120(–175) cm tall, glabrous, with clustered, thick, fleshy, fibrous roots; stem slender to rather stout, striate, strongly branched. Leaves alternate, simple, basal leaves in a rosette, petiole and indistinctly demarcated sheath 1–10 cm long, blade oblong to obovate, up to 25 cm × 6 cm, base attenuate, truncate or cordate, apex obtuse, margins with broad, acuminate, ciliate teeth; stem leaves sessile and clasping the stem, much smaller than the rosette leaves, with longer and darker cilia on the teeth, gradually decreasing in size with height of the stem, upper ones bract-like. Inflorescence a head-like umbel, relatively few together, with 8–11 bracts, alternately larger and smaller, forming a connate spreading involucre up to 1.5 cm long. Flowers bisexual, sessile, 5-

merous; sepals deltoid-ovate, less than 1 mm long; petals obovate, c. 1.5 mm long, white to slightly pink or greenish; stamens free; ovary inferior, 2-celled, styles 2, divergent, straight. Fruit a schizocarp, c. 2 mm long, white-verruculose with rather sharp angles.

Alepidea is a complex genus of about 20 poorly defined species, distributed from Ethiopia to South Africa, with the majority in southern Africa. *Alepidea peduncularis* is part of a variable complex, in which delimitations between species are not sharp. In South Africa the leaves of *Alepidea natalensis* Wood & Evans are similarly used as a vegetable.

Ecology *Alepidea peduncularis* is predominantly a species of montane, often-burnt grassland. It also occurs in open localities in montane forest and *Brachystegia* woodland and on rocky hillsides, at 1000–3800 m altitude.

Genetic resources and breeding *Alepidea peduncularis* is widespread and does not seem to be in danger of genetic erosion. However, the demand for *Alepidea* roots for medicinal purposes may locally also threaten populations of *Alepidea peduncularis*.

Prospects *Alepidea peduncularis* most probably will remain a vegetable of only local importance. Its nutritional and medicinal properties need further investigation.

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ALLIUM AMPELOPRASUM L.

Protologue Sp. pl. 1: 294 (1753).

Family Alliaceae

Chromosome number $2n = 32, 48$

Synonyms *Allium porrum* L. (1753).

Vernacular names *Allium ampeloprasum* comprises several vegetables of which the most important ones are:

- leek (En), poireau (Fr), alho porro (Po);
- great-headed garlic, elephant garlic (En), ail à grosse tête (Fr);
- pearl onion (En), poireau perpétuel, petit poireau antillais (Fr), alho bravo, alho inglês (Po);
- kurrat (En, Fr).

Origin and geographic distribution *Allium ampeloprasum* sensu lato is a wide complex of wild ecotypes and cultivated plants, originating from an area running from Iran to Portugal and northern Africa. Amongst cultivated plants, great-headed garlic seems to be closest to the wild ecotypes; leek has been more modified by domestication.

Allium ampeloprasum – planted

More or less bulbous leek was well known and cultivated by ancient Egyptians, Greeks and Romans. Modern non-bulbous leek is grown nowadays on all continents, except in areas where high temperatures or heavy rains rule out its cultivation. In Africa leek is produced on a small scale in the Sahel countries during the cool season, and in the East African highlands, mostly around the big cities for Western consumers. Local cultivars of vegetatively propagated leek can be found in the tropics, e.g. in East Africa (Kenya), Indonesia and the West Indies. Great-headed garlic is grown in the highlands in some countries close to the tropics, e.g. Réunion, Saudi Arabia and northern India. Kurrat is grown in the Middle East, pearl onions on a small scale in Europe.

Uses *Allium ampeloprasum* comprises several vegetables of which leek is the most important one worldwide. Leek is used as a cooked vegetable. The 'leek' is the cylindrical pseudostem, developed by deep planting and earthing-up. The green leaves can be used for soups. Sliced leek is often dehydrated for use in soups. Sessile cloves of great-headed garlic can be used in place of garlic, but their taste is less satisfying when raw. This inconvenience disappears with cooking. The leaves of kurrat are used in salads or as a cooked vegetable to add flavour to dishes. Pearl onions are used for

pickling.

Production and international trade Europe is the most important leek-producing continent, with over 500,000 t annually. France is the largest producer. Most international trade is within the European Union. In tropical Africa leek production is minor and no statistics are available. During winters with severe frost in Europe, some of the leek grown in Kenya has been exported to Europe.

Properties Leek (trimmed and outer leaves removed, remaining edible portion 57%) contains per 100 g edible portion: water 90.8 g, energy 93 kJ (22 kcal), protein 1.6 g, fat 0.5 g, carbohydrate 2.9 g, fibre 2.8 g, Ca 24 mg, P 44 mg, Fe 1.1 mg, carotene 735 µg, thiamin 0.29 mg, riboflavin 0.05 mg, niacin 0.4 mg, folate 56 µg, ascorbic acid 17 mg (Holland, B., Unwin, I.D. & Buss, D.H., 1991). The major part of the carbohydrates consists of fructans.

The flavour of leek is linked with the presence of S-alkyl-cysteine sulphoxides, propyl- and methyl-cysteine sulphoxides being predominant in modern leeks. This precursor is transformed into a number of S-containing volatiles (e.g. thiosulphinates) when raw leek is cut. The taste of cooked leek, more appreciated by consumers, is also linked with S-containing volatiles, to which a small amount of saponins may add a little bitterness. In great-headed garlic allyl- and propyl-cysteine sulphoxides are present in leaves and cloves, resulting in a taste intermediate between leek and garlic. Some of the saponins found in leek have in-vitro antitumour activity.

Adulterations and substitutes Leek can be replaced by bunching onions with a long thick pseudostem, such as some cultivars of *Allium fistulosum* L. or 'Beltsville Bunching Onion', a tetraploid seed-propagated cross between *Allium cepa* L. and *Allium fistulosum*. In South Africa *Allium dregeanum* Kunth is collected in the wild by Hottentot people; it is called wild leek, similarly to the wild ecotypes of *Allium ampeloprasum* on both sides of the Mediterranean.

Description Robust erect herb up to 150 cm tall; true stem consisting only of a basal plate or disk, with little or no bulb formation, or with bulbs producing two kinds of cloves, small stiped ones and larger sessile ones; roots adventitious. Leaves distichously alternate; sheath tubular, forming a pseudostem up to 50 cm long; blade linear, up to 50 cm × 7 cm, V-shaped in cross-section. Inflorescence a spherical umbel 4–12 cm in diameter, bearing several hundreds of flowers, on a solid, terete scape up to 150 cm long; umbel subtended by a single, long-pointed spathe shed at flowering. Flowers bisexual, campanulate; pedicel 1–5 cm long; tepals 6, in 2 whorls, free, ovate-oblong, 4–6 mm long, purple or white; stamens 6, the inner ones tricuspid; ovary superior, 3-celled. Fruit a depressed globose to ovoid capsule 2–4 mm in diameter, up to 6-seeded. Seed 2–3 mm × 2 mm, black. Seedling with epigeal germination.

Allium ampeloprasum – 1, habit leek plant; 2, habit of flowering bulbous plant.
Redrawn and adapted by Iskak Syamsudin

Other botanical information The *Allium ampeloprasum* complex comprises wild as well as cultivated elements, and the taxonomy is rather confused. In the literature, cultivated leek is often named *Allium porrum*. Great-headed garlic produces in its bulbs 3–6 very large cloves (up to 60 g). Its stiped cloves, 8–10 mm in diameter, are protected by a hard 'shell' and can remain in the soil for more than 1 year before sprouting. Its very large leek-like umbels do not produce seeds. European bulbous leek has sessile cloves covered by a thin silvery-white skin, and sometimes a few shortly stiped cloves without shell. It is found only in old home gardens, e.g. the 'pearl onion' grown in Germany and the Netherlands. When tropi-

cal vegetatively propagated forms of leek are experimentally grown in temperate countries, they appear to belong to this category, since they produce bulbs, usually with a central spherical clove surrounded by small ones. Some of them never flower under long-day conditions, e.g. the West Indian leek never reached the flowering stage when grown in southern France for 20 years. On the other hand, the Indonesian 'Anak prei' flowers in the Netherlands, its seeds giving a heterogeneous progeny. The behaviour of African vegetatively propagated leek under long-day conditions is unknown.

Modern leek has been bred during more than two centuries for elimination of cloves, leading to strictly seed-propagated plants with perfectly cylindrical pseudostems. However, two vestigial cloves may appear at the base of the scape of seed-producing plants. Kurrat (synonym *Allium kurrat* Schweinf. ex K.Krause), cultivated in the Middle East, is a seed-propagated plant looking like a small leek, but grown for successive harvests of green leaves. 'Taree Irani', grown in Iran, is a kurrat-like plant producing in its umbels a mixture of flowers and bulbils.

Seed available in Africa is imported from Western countries, mainly from summer types with pale green leaves and a long soft pseudostem, e.g. 'Gros Long d'Eté', 'Bulgarian', 'American Flag', 'Carentan' and 'Giant Italian'. The winter types with dark green leaves and a short thick hard pseudostem are less often grown and are only suitable for the cool highlands.

Growth and development Vegetative growth in leek occurs at temperatures of 4–25°C, with an optimum at 16–20°C. Even at optimal temperatures germination is slow (10–12 days) compared with other vegetables. A leafy cotyledon appears first, bearing the seed testa at its apex. At optimal temperatures new leaves are formed every 6 days. Plants reach the harvest stage when 15 leaves have appeared, but continue to grow in thickness.

Floral initiation occurs about 180 days after sowing in temperate conditions, plants exposed to low temperatures (5°C) bolting earlier. Growth of the floral stem is enhanced by long days; consequently bolting and flowering rarely occur under tropical conditions. Leek flowers are pollinated by insects. Both self- and cross-pollination occurs. Besides seed, bulbils (topsets) may be formed in the umbel of some cultivars.

Ecology A cool season of at least 4 months is needed for good growth of leek. Leek cultivation in hot humid lowlands below 500 m is rarely successful. At higher latitudes during the cool season and at elevations above 1000 m leek is easier to grow. In the lowlands, 130 days are needed (60 days in the seedbed, 70 days in the field) for harvesting leek more than 1 cm in diameter. When temperatures are above the optimum (e.g. 22°C at night, 30°C during the day), leaf senescence can be as rapid as the production of new leaves, resulting in no diameter growth at all. Plants may be harvested from 100–120 days after transplantation, but may be kept in the field longer as they continue to grow thicker (20–25 mm). For leek cultivation, soils must be deep, loose, their pH higher than 5.6, with a good amount of organic matter.

Propagation and planting In the tropics leek is propagated either by seed or by tillers.

One g contains 300–400 seeds. Leek seed is normally imported. It does not show dormancy. For modern cultivars, about 1000 seeds are sown per m^2 in a nursery roofed with plastic or with palm leaves, the roofing being removed after emergence of seedlings. Seedlings 15–20 cm tall and pencil-thick are transplanted vertically into holes 10–12 cm deep, at a rate of 200,000/ha, e.g. at a distance of 10–15 cm in the row and 30–45 cm between rows. To obtain long pseudostems, planting is done at the bottom of furrows to facilitate earthing-up. For vegetatively propagated leek, lateral shoots (tillers) are planted in the same way as seedlings.

Management A harvest of 20 t/ha removes about 65 kg N, 10 kg P, 75 kg K, 35 kg Ca, 3 kg Mg and 15 kg S from the soil. Fertilization with 5–20 t/ha of organic manure and an adequate quantity NPK including sulphates is recommended, as well as liming if necessary.

Diseases and pests The most important leaf disease is purple blotch (*Alternaria porri*), to which plants are more susceptible on calcium-deficient acid soils. It can be controlled with dithiocarbamate fungicides or iprodione. In the lowlands, roots are invaded by *Pyrenochaeta terrestris* in the same way as for garlic or onion. The roots and basal plate can be destroyed by the fungus *Sclerotium cepivorum* or the nematode *Ditylenchus dipsaci*, potentially noxious in the tropics if introduced in highlands (e.g. by cultivation of contaminated garlic cloves). Rust (*Puccinia* spp.) and white tip (*Phytophthora porri*), which are major diseases

in temperate areas, have not been recorded in Africa.

Thrips tabaci can cause serious losses in yield and quality. It can be controlled by insecticides, but also overhead irrigation can decrease thrips infection. This method of irrigation is also beneficial against purple blotch if applied between 11 a.m. and 3 p.m.

Harvesting Leek is harvested 70–120 days after planting, but may be kept in the field longer. The plants are dug up with a spade, washed, the dried or yellowing leaves eliminated with their sheaths, the remaining leaves trimmed, and roots cut at 1–2 cm. Following consumers' preference, the green foliage is cut shorter or longer. For vegetatively propagated leek the thicker pseudostems are sold, the thinner lateral shoots kept for own use or for a new planting.

Yield Under tropical conditions, 15–20 t obtained 70 days after planting in the lowlands during the cool season can be considered a good yield; 40 t/ha might be obtained at elevations of 1500–2000 m if purple blotch is perfectly controlled.

Handling after harvest Freshly harvested and carefully cleaned leek can be kept 2–3 days, vertically packaged together in baskets or perforated plastic bags. Storage at 0°C is possible for up to 60 days.

Genetic resources Apart from the vegetatively propagated tropical types (Kenya, Indonesia, West Indies, Haiti), apparently old introductions from temperate countries, there are no tropical leek cultivars. Germplasm collections of European and oriental leek cultivars are preserved as seeds in institutes in Wellesbourne (United Kingdom), Wageningen (Netherlands) and Washington (United States). A number of wild *Allium* species, more or less closely related to *Allium ampeloprasum*, are preserved at the Royal Botanic Gardens Kew, United Kingdom.

Breeding Major breeding objectives in temperate countries are yield, uniformity and disease resistance. Leek can be considered an allogamous autotetraploid with 20–30% self-pollination in seed-production fields. Nowadays seed companies either go on maintaining traditional open-pollinated cultivars under permanent mass selection pressure, or offer F_1 hybrids. Plant vigour loss by selfing is about 30% for the first generation and 40% between S_1 and S_2. F_1 hybrids are based on male sterility. F_1 hybrid leek has 20% higher yields and is more uniform. The rationale behind this is the exclusion of progeny resulting from self-pollination. F_1 cultivars can have a different genetic background but they always have the male sterile parent in common. This line is vegetatively propagated via in-vitro multiplication and/or formation of bulbils, obtained in the umbels by early flower ablation and exposition to photoperiods of 20 hours. Cytoplasmic male sterility has recently been transferred from *Allium cepa*. No special breeding work for or in tropical countries has been reported.

Prospects Leek is a productive and highly nutritious vegetable. The need for an *Allium* used as a cooked vegetable can be satisfied by *Allium ampeloprasum* or *Allium fistulosum*. If leek is preferred, breeding for tropical conditions could be an interesting objective. Since there seems to be a general cross fertility between all tetraploid *Allium ampeloprasum* types, a wide array of subtropical parents would be available. An example of such research is a cross between leek and kurrat realized in the Netherlands to introduce virus resistance. The advantages and disadvantages of vegetatively and seed-propagated leek in tropical conditions should be studied. Breeding for resistance to purple blotch would be interesting too.

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ALLIUM CEPA L.

Protologue Sp. pl. 1: 300 (1753).

Family Alliaceae

Chromosome number $2n = 16$

Synonyms *Allium ascalonicum* auct.

Vernacular names Onion, bulb onion; shallot (En). Oignon; échalote (Fr). Cebola; chalota, cebolete (Po). Kitunguu (Sw).

Origin and geographic distribution *Allium cepa* (including seed-propagated onions and most shallot types) is only known from cultivation. It probably originates from Central Asia

Allium cepa – planted

(between Turkmenistan and Afghanistan) where some of its relatives still grow in the wild. The closest among them are *Allium vavilovii* Popov & Vved. from southern Turkmenistan and northern Iran, with which it gives 100% fertile hybrids, and *Allium asarense* R.M. Fritsch & Matin from Iran. *Allium oschaninii* O.Fedtsch. (Uzbekistan and neighbouring countries), which used to be considered the ancestor of *Allium cepa* cannot be crossed successfully with the cultivated onion, but its domestication seems to be the origin of some European 'shallots' ('échalote grise' in France, 'Scalogno di Romagna' in Italy). From Central Asia the supposed onion ancestor probably migrated first towards Mesopotamia, where onion is mentioned in Sumerian literature (2500 BC), then to Egypt (1600 BC), India and South-East Asia. From Egypt, *Allium cepa* was introduced into the Mediterranean area and from there to all the Roman empire.

Traditional tropical African cultivars may have been introduced either from southern Egypt, or from India via Sudan to Central and West Africa, as genetically heterogeneous seed or bulb lots, then bred by local farmers into better adapted seed-propagated onions, or selected to become shallots. *Allium cepa* as bulb onion and/or shallot is probably cultivated in all countries of tropical Africa. Important production areas for bulb onion are Senegal, Mali, Burkina Faso, Ghana, Niger, Nigeria, Chad, Sudan, Ethiopia, Kenya, Tanzania, Uganda, Zambia and Zimbabwe.

In the lowlands between 10°N and 10°S shallots replace onions because the temperature is too high for vernalization and seed production, and the climate too humid. The short vegetative cycle of shallots (60–75 days) gives the possibility of two crops a year, especially in the four-seasons climate along the Gulf of Guinea. Yellow or red/purple shallots are grown in Guinea, Côte d'Ivoire, Ghana, Benin, Nigeria, Sudan, Ethiopia, Uganda, Kenya, Tanzania, and on both banks of the Congo River near Brazzaville (Congo) and Kinshasa (DR Congo). The spicy taste and high dry matter content (15–18%) of shallots have made them attractive for growers farther from the equator, in many areas where common onions are also produced, e.g. by the Dogon in Mali, or in Cape Verde.

Uses Bulbs of *Allium cepa* are a popular vegetable everywhere. They can be used raw, sliced for seasoning salads, boiled with other vegetables, or fried with other vegetables and meat. They are an essential ingredient in many African sauces and relishes. If consumed in small amounts for their pungency, they can be considered as a condiment. The leaves, whole immature plants (called 'salad onions' or 'spring onions'), or leafy sprouts from germinating bulbs (called 'cébettes' in southern France) are used in the same way. Locally, immature flower heads are also a popular food item. In parts of West Africa, leaves still green at bulb harvest are pounded, then used to make sun-dried and fermented balls, which are used later for seasoning dishes. Sliced raw onions have antibiotic properties, which can reduce contamination by bacteria, protozoa or helminths in salads. In traditional medicine onion is used externally to treat boils, felons, wounds and stings, and internally to relieve coughs, bronchitis, asthma, gastro-intestinal disorders and headache.

Production and international trade FAO statistics report the worldwide annual production of dry onion bulbs in 2001 as 49 million t, continental China being the largest producer with 15 million t; India produced 5 million t and the United States more than 3 million t; Brazil, Indonesia, Iran, Japan, South Korea, Pakistan, Russia, Spain and Turkey each more than 1 million t. Some countries producing more than 500,000 t for a relatively small population are important exporters to Africa, e.g. the Netherlands. Shallots are either included in bulb onion data, or combined with green onions. Mexico reports a production of over 1 million t in the latter category. However, some of these figures should be considered critically, e.g. for Asian countries where 'on-

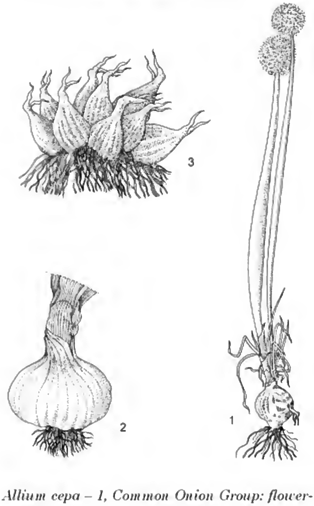
ions' may include *Allium fistulosum* L. Besides, the data are often incomplete for tropical countries. The production of tropical Africa reaches 1.5 million t, compared with 2.2 million t for non-tropical Africa. It is difficult to know if these 'dry onions' are all seed-propagated, or if they include shallots. Most African tropical countries import onion bulbs, either from Niger, which exports an important part of its 200,000 t production, or from Europe or South Africa. Shallots are exported from northern Côte d'Ivoire and Mali to the neighbouring countries.

Properties The dry matter content of onion or shallot bulbs ranges from 7–18%; shallots generally have a higher dry matter content than onions. The composition of the dry matter is rather constant; the variation in the composition of fresh onion and shallot is mainly caused by variations in moisture content. Bulb onions contain per 100 g edible portion (91% of product as purchased): water 89 g, energy 150 kJ (36 kcal), protein 1.2 g, fat 0.2 g, carbohydrate 7.9 g, fibre 1.5 g, K 160 mg, Ca 25 mg, P 30 mg, carotene 10 μg, thiamin 0.13 mg, riboflavin trace, niacin 0.7 mg, folate 17 μg, ascorbic acid 5 mg. The composition of immature plants (young leaves and peeled bulb) per 100 g edible portion (69% of product as purchased) is: water 92.2 g, energy 98 kJ (23 kcal), protein 2.0 g, fat 0.5 g, carbohydrate 3.0 g, fibre 1.5 g, K 160 mg, Ca 75 mg, P 29 mg, carotene 620 μg, thiamin 0.05 mg, riboflavin 0.03 mg, niacin 0.5 mg, folate 54 μg, ascorbic acid 26 mg (Holland, B., Unwin, I.D. & Buss, D.H., 1991). The carbohydrates consist of glucose, fructose, sucrose and fructans. In bulbs with a low dry matter content, glucose and fructose are predominant (75% of the carbohydrates in bulbs with 7.5% dry matter). Fructans on the contrary are predominant when the dry matter content is high (90% of the carbohydrates in bulbs with 17% dry matter).

Fresh onion bulbs contain sulphoxides, the most important of which is propenyl cysteine sulphoxide. Upon bruising the bulb, these are degraded by alliinase to release pyruvic acid and alkyl-thiosulphinates, which rapidly turn into sulphides and disulphides. The volatile alliinase product (Z)-thiopropanal-S-oxide (synonym: propenyl sulphoxide) is the well-known lacrimatory factor in onions. The degradation of sulphoxides can be influenced by external conditions such as boiling and frying, which explains the occurrence of different flavours. The combined taste of sulphides and caramelized sugars gives the flavour to fried onion. The pungency and flavour of onions vary, depending on variety, growing conditions (e.g. temperature and soil nitrogen and sulphur content) and storage conditions.

In in-vitro experiments onion showed antibacterial and antifungal activity against both gram-positive and gram-negative bacteria (including enteropathogens), pathogenic yeast (*Candida* spp.) and some skin-pathogenic fungi. Onion juice has been shown to have anti-hyperglycaemic and anti-asthmatic properties. The best investigated medicinal activity, however, is the effect on platelet aggregation. Onion extracts have shown in-vitro activity against platelet aggregation, but clinical tests have shown conflicting or inconsistent results. Regular consumption of onion has been reported to reduce the risk of stomach cancer.

Description Biennial glabrous herb, usually grown as an annual from seed or bulbs, up to 100 cm tall; real stem very short, formed at the



Allium cepa – 1, Common Onion Group: flowering plant; 2, Common Onion Group: basal part of plant with mature bulb; 3, Aggregatum Group: mature bulbs.
Redrawn and adapted by Iskak Syamsudin

base of the plant in the form of a disk, with adventitious roots at base; bulbs formed by the thickening of leaf-bases a short distance above the true stem, solitary or in clusters, depressed globose to ovoid or oblate, up to 20 cm in diameter, variously coloured. Leaves 3–8, distichously alternate, glaucous, with tubular sheath; blade D-shaped in cross section, hollow, up to 50 cm long, acute at apex. Inflorescence a spherical umbel up to 8 cm in diameter, on a long, erect, terete, hollow scape up to 100 cm long, usually inflated below the middle; umbel initially surrounded by a membranous spathe splitting into 2–4 papery bracts. Flowers bisexual, stellate; pedicel slender, up to 4 cm long; tepals 6, in 2 whorls, free, ovate to oblong, 3–5 mm long, greenish white to purple; stamens 6; ovary superior, 3-celled, style shorter than stamens at anthesis, later elongating. Fruit a globular capsule 4–6 mm in diameter, splitting loculicidally, up to 6-seeded. Seeds c. 6 mm × 4 mm, black.

Other botanical information *Allium cepa* is nowadays considered as divisible into two large cultivar-groups: Common Onion Group, with large, normally solitary bulbs, reproduced from seed or from seed-grown bulblets ('sets'), and Aggregatum Group, with smaller, several to many bulbs forming an aggregated cluster, originating from a single mother bulb. A cultivar of *Allium cepa* will be considered as a 'shallot' (belonging to Aggregatum Group) if more than 200 buds are present in one kg of mother bulbs, and if, under suitable climatic conditions, most of these buds give new bulbs. This definition does not exclude that, if the sprouts of a common onion grow under conditions unfavourable for floral initiation, they may form smaller bulbs, or, on the contrary, that sprouts from a shallot mother-bulb may produce floral stems when vernalized.

Only short-day cultivars of Common Onion Group, with a critical daylength close to 12 hours, can give bulbs in tropical Africa. They belong to 3 main categories:

– Traditional tropical African cultivars, e.g. 'Violet de Galmi', 'Blanc de Soumarana' (Niger), 'Violet de Garango' (eastern Burkina Faso), 'Bawku' (northern Ghana), 'Red Kano' (northern Nigeria), 'Violet d'Abéché' (eastern Chad), 'Malanville' (Benin), 'Rouge de Tana' (West Africa) and 'Tana' (adaptation from 'Rouge de Tana' in Madagascar). Recent selection in this category has given 'Yaakar', 'IRAT 19' and 'Noflaye' (Senegal). Bulbs of these cultivars have a high dry matter content and store well under natural conditions. 'Noflaye' is selected for resistance to bolting. Big red onion cultivars traditionally grown in Sudan are more like the West African onions, but white and yellow cultivars may have originated from Egypt.
  Red or purple onions are also grown in East Africa, but their names, e.g. 'Bombay Red' and 'Red Globe' indicate an Indian origin. These cultivars may have been maintained locally for long periods of time (e.g. a 'Bombay Red' strain in Tanzania) resulting in varieties adapted to local seed production and differing from the original foreign source material.
– Mediterranean cultivars, either under their original name, e.g. 'Babosa', or 'Valenciana Temprana' ('Jaune Hâtif de Valence') from Spain, or after breeding for increased earliness in the southern United States, e.g. 'Texas Grano' cultivars, or 'Granex' F_1 hybrids. Similar selection work in South Africa gave the open-pollinated cultivar 'Pyramid'. However, even with the earliest of these cultivars, 'Texas Early Grano 502', which can give bulbs at latitude 0°, no satisfactory seed production can be achieved in tropical Africa. These onions are larger than the traditional African ones, but their dry matter content is considerably lower (7–10% versus 12–16%) and their storage life is short under ambient conditions.
– Cultivars of the Creole group. The 'Red Creole' type of onion may have been developed in Louisiana from African onions brought to the New World at the time of the slave trade. American catalogues traditionally offer 'Red Creole' and more recently 'Yellow Creole' and 'White Creole'; their dry matter content is relatively high, but their seed producing ability in tropical conditions has decreased. Creole onions store better than the Grano/Granex types, but not so well as the West African lines. They tend to be popular in countries of East and southern Africa, where there is no tradition of local seed production, but where red onions are preferred. Their bolting resistance is higher than that of onion cultivars imported from India, hence their suitability for high altitude growing areas, e.g. in Kenya.

Several seed companies worldwide have undertaken breeding work to improve tropical short-day onions, including Technisem in West Africa and East West Seed Company in Zimbabwe and Asia. Improved cultivars resulting

from this breeding work are commercially available; these include 'Noflaye' (Technisem - later bolting selection from 'Violet de Galmi'), and 'Red Pinoy' (East West Seed Company - a long storage and late bolting red onion derived from a red polycross). The islands Réunion, Mauritius and Rodrigues have an onion growing tradition too, e.g. 'Rouge de Châteauvieux', a red/pink onion bred more than 100 years ago from a fortuitous cross between the French 'Rouge Pâle de Niort' and an Indian cultivar. In Mauritius and Rodrigues smaller, very pungent 'Local Red' onions are also grown and maintained locally.

Growth and development The vegetative growth in *Allium cepa* in temperate areas follows a growth curve with a minimum at 6°C, a relatively flat optimum at 20–28°C, and a maximum at 34°C. Tropical cultivars are possibly adapted to a somewhat higher range of temperatures; research in Sudan has shown that temperatures of 17–22°C at night and 45°C during daytime retards bulbing but that the plants slowly continue to produce leaves, even when the daylength promotes bulbing. At lower temperatures but the same daylength, bulbing proceeded normally.

Allium cepa requires long days for bulb initiation and enlargement, but the critical daylength is relatively short, at less than 12 hours for traditional tropical cultivars, or for the earliest Mediterranean cultivars. There is no true juvenile stage in *Allium cepa*; bulbing can be initiated in very young plants if days are longer than the critical length and temperatures higher than 20°C. The spectral composition of the light received by the leaves has an important influence too: bulbing is promoted when the red/far-red ratio is lowered by high-density planting, intercropping or even by weeds.

Bulbing starts from the outer, still fleshy leaf-sheaths and ends with the formation of specialized fleshy scales at the centre of the bulb, which are effectively thickened leaf sheaths with undeveloped blades. The mature bulb consists of the disk or base plate, in fact the real stem, the skin (outermost dry leaf sheaths), false scales (fleshy sheaths of complete leaves), true scales (fleshy sheaths of bladeless leaves) and primordial sprout leaves. At maturity, the leaf blades start to wither, while the water and assimilates from them are rapidly transported into the swelling bulb. When the leafy tops have 'fallen' by softening of the now hollow pseudo-stem, maturation is complete and the bulbs enter a phase of more or less intense dormancy, which varies in depth between cultivars. This dormancy is most quickly eliminated at cool temperatures, at 7–12°C.

Floral initiation does not depend on daylength, but requires vernalization. Temperatures below 10°C are adequate for temperate or Mediterranean cultivars, and several nights below 15°C for traditional tropical onions, and below 18°C for tropical shallots. Vernalization can be applied to growing plants or to bulbs in storage, provided that the plants are older than a 'juvenile stage' (6–7 leaves) or the bulbs more than 2.5 cm in diameter. Floral initiation is characterized by changes in shape at the centre of the meristematic apex, the primordial sprout leaves start to grow, using the food reserves stored in the bulb, and soon the inflorescence buds become visible at the centre of the leafy shoots. Onion is a facultative cross-pollinator, the percentage of selfing amounting to 10–20%. The flowers are protandrous. Pollination is by bees, bumble-bees or flies. When mature, the fruits dehisce, allowing shedding of the seeds.

Ecology Optimal vegetative growth and good bulb maturation are generally obtained under dry and cool conditions. Bulb maturity is promoted by a combination of increasing daylength and rising temperatures, whereas withdrawal of irrigation also hastens bulb maturation. Onions and shallots can grow on any soil with pH above 5.6, but adequate calcium nutrition is essential for good vegetative development and disease tolerance. Onion crops in the tropics are often grown under irrigation between rainfed crops of cereals.

Propagation and planting Three methods are practised for onion production:

- The production of transplants in nurseries sown at a rate of 500–1000 seeds/m^2 (1.5–3 g/m^2) is convenient for the small farmer. About 40–50 days after sowing the young plants, as thick as a pencil, are transplanted at densities of 16–36 plants/m^2. A row spacing of 30–35 cm is suitable to facilitate hand weeding. At higher densities the yield will be higher, but the bulbs smaller.
- Direct sowing is the normal large-scale method in temperate countries. In the tropics this is rarely used, because it needs a high standard of husbandry, precision sowing equipment and considerable skill in the use of herbicides and irrigation. Young seedlings easily perish with heavy rains. Furthermore, a direct-sown crop occupies the plots 50 days

earlier.

- Planting 'sets' is used in temperate countries for early production. Very small mature bulbs weighing less than 3 g (diameter 1.6 cm) are obtained by a late sowing (days longer than 12 hours, mean temperatures higher than 25°C) at the same density as for transplants; they are harvested and replanted after storage at normal density for the early production of big bulbs. This method is sometimes applied in the tropics (e.g. in Senegal, for the production of early crops), though it could be more widely used with advantage. Bulbils, i.e. the very small bulblets that may develop in the inflorescence, can be used for multiplication, but this is rarely done.

For shallot production, mother bulbs, weighing 3–10 g, are planted at a rate of 25–50 bulbs/m². Small mother bulbs tend to give a few large shallots, large mother bulbs a larger number of small shallots. Dense planting gives smaller plants and fewer bulbs per plant but a higher total yield. Seed of short-day shallots is now available from some companies. For shallots grown twice a year near the equator, planting should be timed to allow harvesting during one of the dry seasons.

For common onion, the seed yield for 1 ha planted with 5 t of mother bulbs can reach 500 kg. African farmers have developed original techniques for onion seed production. In Senegal, Niger and neighbouring countries, only the lower half of the mother bulb is planted, the upper half being utilized to make sun-dried onion paste. In northern Nigeria, young shoots from the mother bulb are separated and transplanted. Many farmers in West Africa practise seed-to-seed production, because it is easy and not costly. However, this system aggravates the risk of premature bolting in the first year. Local consumers are accustomed to finding dry young scapes inside the bulbs, and sometimes a market exists for the edible scapes and buds. More exigent markets consider the presence of young scapes a defect.

Seed production from Mediterranean cultivars could be obtained under tropical conditions by an adequate vernalization of mother bulbs in refrigerated stores, but such a method would probably be too costly and therefore the seed is usually imported from temperate regions. In Brazil, where electricity is available in rural areas, it is done succesfully.

Onion seed must be harvested under dry conditions, treated gently during cleaning and stored as quickly as possible under dry conditions. It deteriorates rapidly, in only a few months under humid tropical conditions, but can be stored for several years when kept dry in hermetically sealed packages or in containers with a desiccant. An appropriate seed moisture content for long-term storage is 7–8% or less.

Management For good production onions need fertile soil. The best onion yields in African experiment stations were obtained under high fertilizing with 120–60–150 kg/ha NPK. The fertilizers should also contain enough sulphates. The strong mycorrhization of onion roots by *Endogonaceae* allows them to exploit the phosphorus reserves of the soil. Nitrate-N is more favourable for onion than ammonium-N, which should not be used alone. Organic matter is useful if fully decomposed, but not when it releases ammonia. Bulbs obtained with excessive N fertilization do not store well, so ideally the N supply should be adequate for the young and bulbing plants but be exhausted by harvest time. For shallots, the vegetative cycle being shorter and the potential harvest lower, recommended fertilizer applications are half of the figures indicated above.

Furrow irrigation is common with onions planted in double rows on beds 40–50 cm wide. Most farmers irrigate onions manually overhead, applying 3–4 l/m² on dry days. This overhead or sprinkling irrigation is not very appropriate for onions because it stimulates fungal leaf diseases. Drip irrigation is the most suitable method, but is expensive and so far rarely used. Saline water is not well tolerated. Irrigation should be stopped 20 days before the harvest.

During crop establishment much hand weeding is needed because onions are slow growing and do not compete well with weeds. Many weeds may occur, the worst being nut grass (*Cyperus rotundus* L.).

Diseases and pests The most important soilborne disease in semi-arid regions is pink root (*Pyrenochaeta terrestris*); roots rot during bulb enlargement, resulting in small bulbs. The fungus can persist for several years in the soil and invades roots of other *Allium* species (e.g. garlic) and grasses (e.g. maize). A 5-year rotation without *Allium* species or cereals is recommended, and if possible solarization, at least for seedbeds. Screening of cultivars from the United States and Brazil resulted in the selection of 'Texas Early Grano 502' resistant to pink root. However, its roots were affected

by pink root in Senegal, under conditions of monocropping and irrigation with saline water. Breeding for higher levels of resistance is carried out in Brazil. Optimum temperatures for the development of white rot (*Sclerotium cepivorum*) and stem-and-bulb nematode (*Ditylenchus dipsaci*) are relatively low, and therefore these diseases have not been frequently reported in tropical Africa. Basal bulb rot caused by *Fusarium oxysporum* is sporadically reported in Africa. Here too, resistance has been found in plants from a number of countries (Italy, United States, Brazil).

The most important leaf disease under rainy conditions during bulb enlargement is purple blotch (*Alternaria porri*). Onions grown in acid, calcium-deficient soils are especially susceptible; lime or powdered limestone applied in the planting furrow can be useful. Fungicide such as iprodione, daconil and dithane can be effective. However, the waxy epidermis of onion leaves can retain only small droplets. *Glomerella cingulata*, the twister disease, has caused heavy losses in onions in the Sahel and northern Nigeria. This fungus is the perfect stage of the asexually propagated fungus *Colletotrichum gloeosporioides*, which causes anthracnose in shallots in Indonesia and Brazil. Several fungi are seedborne. A powdery mildew (*Leveillula taurica*) invades onion leaves in coastal areas of West Africa causing chlorotic leaf spots. Downy mildew (*Peronospora destructor*) is a damaging disease in the East African highlands. Storage rots caused by bacteria or fungi (e.g. *Erwinia* spp., *Pseudomonas aeruginosa*, *Aspergillus niger*) may damage the crop especially if the bulbs have endured too high temperatures during drying on the soil. The principal cause is *Aspergillus niger*, a common ubiquitous and saprophytic black mould. A correlation was demonstrated between seed infestation by *Aspergillus niger* and black mould in storage. Therefore clean or disinfected seeds should be used. Disinfection of onion stores is useful too, as well as the destruction of cockroaches, which carry the spores. There is a reciprocal interaction between bulb sprouting and storage rots: bacterial or black mould infection can induce premature sprouting, and the flesh of sprouting bulbs is more susceptible to rot. Virus diseases are of lesser importance in onions and shallots in Africa, but they can be important elsewhere, e.g. on shallots in Indonesia.

Some *Spodoptera* or *Agrotis* caterpillars cut the young plants at soil level or eat the leaves. The principal insect pest of onions and shallots is *Thrips tabaci*, which can be controlled with insecticides, but daily spraying with pure water or overhead irrigation is fairly efficient too. Spraying with insecticides against caterpillars often aggravates thrips damage, because it kills the natural enemies of thrips. Some cultivars are thrips-tolerant, e.g. 'Yaakar', bred by the Centre pour le Developpement de l'Horticulture (Senegal). Four lines bred by INA-Cabo Verde (Cape Verde) are also resistant to both thrips and pink root.

Harvesting African cultivars or 'Texas Grano' can be harvested 70–80 days after transplanting (120–130 days after sowing) or planting of sets, and later cultivars 150–180 days after sowing. In coastal areas of Senegal, sets of 'Violet de Galmi' planted in October can be harvested in January, 'Violet de Galmi' or 'Texas Grano' sown between September and January are harvested from February to May, and 'Jaune de Valence' sown between January and March is harvested from June to August. This staggering of production is more difficult in more inland parts of Senegal, where most of the crop is sown in December, to be harvested in March. The harvest occurs before daily temperatures are over 38°C, at latitudes of 10–25°. Shallots have a cycle from planting to harvesting of about 75 days under the shortest days and cooler temperatures, with some inflorescences produced. Under longer days, the cycle is still shorter (60 days, no flowering).

Yield For 'Violet de Galmi' 50–60 t/ha has been obtained in experiment stations under optimal fertilization and irrigation, and up to 80 t/ha for 'Texas Early Grano'. Yields obtained by small farmers reach 10–20 t/ha. Traditional yields of shallots are about 8 t/ha, but they can reach 18 t/ha under optimal conditions.

Handling after harvest Harvested plants are usually dried for some days in the field, with leaves of one plant covering another; they are then tied in bunches with their leaves, or the leaves are cut off and the bulbs gathered in bags or crates. The necks should be trimmed at about 4 cm above the bulb to avoid damaging the fleshy bulb tissues. When the air temperature is above 38°C, the soil surface temperature can rise higher than 45°C, especially on black soils, so the bulbs are best dried under shade to avoid heat damage.

In equatorial regions, e.g. in Kenya, onions are produced continuously and thus the keeping quality is of less importance. In climates between latitudes 10° and 25° there are at least

six months during which freshly harvested onions are not available on the market, and there the choice of cultivars with good keeping quality is important. There are large differences between cultivars for storability; a high dry matter content is linked with good storage characteristics. Notable for poor storage are 'Texas Grano' types. Onion bulbs deteriorate most rapidly at temperatures which quickly eliminate their dormancy (5–15°C). They can be kept longer at temperatures close to 0°C, or at 20–30°C, but they should be dried properly, at an optimal relative humidity of 65–80%. Storage rooms need to be only free-ventilating if bulbs are kept as hanging bunches or braids, in stacked, well-ventilated crates or on shelves. Textile bags of 25–50 kg should be placed so that air can circulate around them. Bulk storage in layers more than 40 cm thick or in bins of more than 1 m^3 cannot be practised without forced air circulation.

Dormancy of onion bulbs can be enhanced by application of a plant growth inhibitor, maleic hydrazide (MH), 15 days before harvest; it is sprayed on the plants before the green colour has disappeared from the leaves, from where it is transported to the growing points. Imported bulbs can have been produced under MH use, since European legislation does not require mention of this treatment.

Genetic resources Important collections of onion germplasm are maintained in temperate countries: United Kingdom, Netherlands, Hungary, United States and Japan. Collections of tropical cultivars are maintained in India, Brazil, Colombia and at AVRDC (Taiwan). In West Africa, several countries cooperate for collection, maintenance and characterization of traditional onion cultivars, continuing the work initiated during the 1960s and 1970s by CDH and IRAT in Senegal. The largest number of national onion accessions is kept at the Centre Régional de Recherche Agronomique (CERRA), Maradi (Niger) and the largest regional collection is stored at the Centre Régional de Recherches Environnementales et Agricoles (CRREA), Farako-Bâ (Burkina Faso).

In Indonesia, which is the world leader in shallot production (390,000 t), an important shallot collection is preserved at Lembang. In Africa, there are two substantial shallot collections: at Centre de Recherche Agronomique (CRA), Bareng (Guinea) and at the Centre National de Recherche Agronomique (CNRA), Bouaké (Côte d'Ivoire).

Breeding *Allium cepa* is insect-pollinated, allogamous and has a severe inbreeding depression, but there is no system to prevent self-fertilization. Open-pollinated cultivars are therefore composed of plants heterozygous for many genes, except for those involved in bulb characters. Not less than 40–50 plants must be grown together under isolation for maintenance of a cultivar without inbreeding depression, and mass selection pressure must be permanent. In this way it was demonstrated that the propensity of 'Violet de Galmi' to premature bolting could be eliminated by saving seeds only from plants that have produced good bulbs without bolting in the first year. Genetic material is available and research is carried out at several national institutes in Africa to reduce onion bolting in the first year.

Three levels can be considered for onion breeding:

- Selection within a cultivar for interesting characters, such as earliness, insect or disease resistance, or male sterility.
- Crosses between onion cultivars. The thrips-resistant 'Yaakar' was obtained by crossing 'Violet de Galmi' and 'Roxa do Traviu'. A short critical daylength is usually dominant in crosses between tropical and temperate cultivars.
- Interspecific crosses which are possible with *Allium galanthum* Kar. & Kir. (for male sterility), *Allium fistulosum* L. (with great difficulties for gene introgression following a nearly sterile F_1 generation), and *Allium roylei* Stearn (resistance to downy mildew and *Botrytis* leaf blight). More recently the use of *Allium roylei* as a bridge species between onion and *Allium fistulosum* has been proposed for introgression of *Allium fistulosum* genes into *Allium cepa*. *Allium fistulosum* seems to be tolerant to purple blotch and pink root disease, but it remains to be seen whether it offers true resistance genes, or if these tolerances are linked to the non-bulbing habit. A complicating factor is that *Allium roylei* is resistant to purple blotch, but susceptible to pink root.

Onion F_1 hybrids based on cytoplasmic male sterility are promoted by many seed companies. Their value has been contested for tropical countries, since the yield superiority to open pollinated cultivars is not always significant (e.g. 'Texas Early Grano' versus 'Granex'), and their homogeneity is less perfect than in tomato or cabbage hybrids, since the parent lines have been homogenized by only a few (1–2) selfings. Their principal interest for seed-

grown crops is the absence of seeds resulting from selfings that give weak plants.

Sowing seed from shallot clones is an easy way to demonstrate their heterozygous nature: purple shallots from Brazzaville gave some white ones in their progeny. Even selfing of a clone will give 2–3% superior plants which in addition will be virus-free. Some European seed companies have recently proposed true-seed shallots for tropical as well as for temperate countries, the seeds giving rise to small shallot-like bulbs. True-seed shallots are not legally recognized everywhere as shallots, in which case they are considered onions. True-seed shallots have phytosanitary advantages. The bulbs obtained in this way could be vegetatively propagated a few times by the farmers, but they would quickly lose the advantage due to new virus infections. In addition, propagation by seed is more economical than vegetative propagation.

Prospects In onion and shallot greater progress is expected from breeding than from improved agronomy. There is a great need for African-bred onion cultivars adapted to different ecological zones and consumers. Increased self-sufficiency for onion seed and shallot bulbs in tropical African countries, better yields and quality rewarding the work of African farmers should be the aims of national institutes and that of seed companies. Both the relatively inexpensive experimental work for the preservation and improvement of African onion and shallot germplasm, as well as sharing the benefits of more advanced research, such as marker-assisted breeding and interspecific crosses, should be involved to reach the aforementioned aims.

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Authors C.-M. Messiaen & A. Rouamba

ALLIUM FISTULOSUM L.

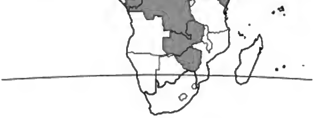
Protologue Sp. pl. 1: 301 (1753).

Family Alliaceae

Chromosome number $2n = 16$

Vernacular names Welsh onion, Japanese bunching onion (En). Ciboule (Fr). Cebolinha, cozida (Po).

Origin and geographic distribution *Allium fistulosum* is only known in cultivation and probably originated in north-western China. DNA studies indicate that it was derived from the wild *Allium altaicum* Pall., which occurs in Siberia and Mongolia, where it is occasionally collected as a vegetable for local use or for export to China. Cultivation of *Allium fistulosum* dates back to at least 200 BC in China. It reached Japan before 500 AD and spread further to South-East Asia and Europe. 'Welsh' in the name welsh onion is probably related to the old German 'welsche' meaning foreign, and has no connection with Wales in the United Kingdom. In China *Allium fistulosum* is the most important *Allium* species fulfilling the culinary role of both the common onion and leek in Europe; in Japan it is now second in importance to the bulb onion (*Allium cepa* L.). The crop is grown throughout the world, but the main area of cultivation remains eastern Asia from Siberia to Indonesia; elsewhere it is



Allium fistulosum – planted

mainly a crop of home gardens. In Africa it is locally important only and is reported from Sierra Leone, Ghana, Cameroon, Congo, DR Congo, Sudan, Kenya, Zambia and Zimbabwe. A leaf onion reported from Nigeria probably also belongs to *Allium fistulosum*.

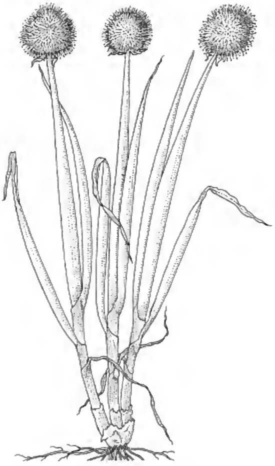
Uses Two types of *Allium fistulosum* are grown and sometimes distinguished as cultivar-groups: Japanese Bunching Group and Welsh Onion Group. Japanese bunching onion is grown mainly in eastern Asia for its thick, blanched pseudostems and is eaten as a pot-herb, e.g. in sukiyaki and chicken dishes; welsh onion is grown for its green leaves, which are used in salads, or as a herb to flavour soups and other dishes. The latter is most common in Africa. In the Brazzaville-Kinshasa area (Congo and DR Congo), whole plants are harvested and eaten as a boiled vegetable. In South-East Asia (Java) the plants are also eaten whole, either steamed or after heating over a fire for a short time, and in Japan seedlings of 7–10 cm tall are used in special dishes. *Allium fistulosum* has not been used in a processed form until recently, when a dehydration industry started. The product is mainly used as an additive to preprocessed food such as instant noodles. The young inflorescence is sometimes deep-fried and eaten as a snack.
The plants are said to reduce or prevent termite infestation in gardens. Diluted pressed juice is used against aphids in China. The therapeutic qualities attributed to *Allium fistulosum* are many, especially in Chinese medicine. It is used to improve the functioning of internal organs and the metabolism, for the prevention of cardiovascular disorders, and to prolong life. It is further reported to improve eyesight, and to enhance recovery from common colds, headaches, wounds and festering sores.

Production and international trade No worldwide statistics for *Allium fistulosum* are available, as information on its production is often combined with that of other *Allium* spp. China, Japan, Korea, Taiwan and Indonesia are the main producers. In 1984 production in Japan reached 563,000 t from 24,000 ha, in Korea 432,000 t from 19,000 ha.

Properties The nutritional composition of raw green tops per 100 g edible portion is: water 90.5 g, energy 142 kJ (34 kcal), protein 1.9 g, fat 0.4 g, carbohydrate 6.5 g, Ca 18 mg, Mg 23 mg, P 49 mg, Fe 1.2 mg, Zn 0.52 mg, vitamin A 1160 IU, thiamin 0.05 mg, riboflavin 0.09 mg, niacin 0.40 mg, folate 16 μg, ascorbic acid 27 mg (USDA, 2002). The nutritional value of green tops and blanched pseudostems differs, green tops being more nutritious.
The odour of *Allium fistulosum* is not very strong. It is chemically intermediate between the odours of onion and leek. It derives from volatile propyl cysteine sulphoxide (characteristic of leek) and propenyl cysteine sulphoxide (characteristic of onion). These alkyl-sulphoxides are degradation products of non-protein amino acids of the S-alk(en)yl-cysteine group. When cells are damaged the amino acids break down under the influence of the enzyme alliinase into highly reactive sulphenic acids, ammonia and pyruvate. The sulphenic acids then react with other compounds to form a range of disulphides.
A large proportion of the storage carbohydrates are sugars and oligosaccharides. Besides glucose, fructose and sucrose, they consist of maltose, rhamnose, galactose, arabinose, mannose and xylose. Sugar and protein contents increase in plants grown under low temperatures, and this improves eating quality.
Tests showed that welsh onion extracts can modulate vascular tone in vitro in the thoracic aortae of rats. This supports the use in traditional medicine to prevent cardiovascular disorders. Antifungal constituents have been isolated from the seeds.

Description Perennial glabrous herb, growing in tufts, usually grown as an annual or biennial plant, up to 50(–100) cm tall, with indistinct, ovoid to oblongoid bulb up to 10 cm long, lateral bulbs few to several or virtually absent; tunic white to pale reddish brown. Leaves 4–12, distichously alternate, glaucous, with tubular sheath; blade cylindrical, hollow, 10–50(–100) cm × 0.5–2.5 cm, acute at apex. Inflorescence a spherical umbel 3–7 cm in diameter, on a long, erect, terete, hollow scape up to 50(–100) cm long and up to 2.5 cm in diameter; umbel composed either of flowers or of bulbils only; spathe 1, hyaline, persistent, up to 1 cm long, splitting into (1–)2–3 parts. Flowers bisexual, narrowly campanulate to urceolate; pedicel slender, up to 3 cm long; tepals 6, in 2 whorls, free, ovate-oblong to oblong-lanceolate, 6–10 mm long, white with greenish midvein; stamens 6, exceeding tepals, connate at base and adnate to tepals; ovary superior, 3-celled, style slender, exceeding tepals. Fruit a globular capsule c. 5 mm in diameter, splitting loculicidally, few-seeded. Seeds 3–4 mm × 2–2.5 mm, black.

Other botanical information In Europe a



Allium fistulosum – plant habit.
Source: PROSEA

classification into 2 cultivar-groups has been proposed: Japanese Bunching Group, single-stemmed cultivars grown for their thickened pseudostem, and Welsh Onion Group, multi-stemmed cultivars grown for their leaves. A classification into 3 groups is common in Japan: Kaga Group grown in the coolest parts of Japan for its pseudostems; Kujyo Group mainly grown in the warmest parts of Japan and mainly for its leaves; and Senju Group, intermediate in use and ecological requirements.

Superficially there is a strong resemblance to *Allium cepa*, but *Allium fistulosum* does not develop a bulb, although some slight thickening of the base of the pseudostem may occur. Its foliage leaves are somewhat rounder in cross-section, not flattened adaxially. Differences are more prominent in the flowers. In *Allium fistulosum* flowering progresses from the top of the umbel downwards. The flowers lack bracteoles, are larger and campanulate to urceolate, while those of *Allium cepa* have bracteoles, are smaller and stellate.

Allium fistulosum hybridizes easily with *Allium altaicum*: the hybrids have high pollen fertility and form ample seed. Hybridization is also possible with *Allium cepa*. The hybrids are perennial plants forming small bulbs. Several old hybrids between *Allium fistulosum* as female parent and tropical shallots (*Allium cepa* Aggregatum Group) exist. These are known as *Allium ×proliferum*, *Allium ×wakegi* or *Allium fistulosum* var. *caespitosum*. Examples are the Indonesian shallot 'Sumenep', which is well adapted to tropical conditions and never flowers, and the top onion in which the inflorescence is composed of bulbils. In the vegetative stage these plants resemble *Allium fistulosum*. Recent commercial hybrids between *Allium fistulosum* as female parent and *Allium cepa*, grown mainly in the United States and Europe for their green tops, include 'Beltsville Bunching' (a seed-producing tetraploid), 'Louisiana Evergreen' (a sterile diploid) and 'Delta Giant' (a sterile triploid originating from a backcross of the hybrid with *Allium cepa*). Another group of hybrids grown in Japan is Yakura Negi Group. Plants of this group tiller abundantly in spring and summer and are dormant in winter. Their inflorescence produces no flowers but only bulbils; they are propagated by division or by bulbils.

Growth and development *Allium fistulosum* is a perennial plant, grown commercially mostly as an annual, but in home gardens also as a perennial. It does not have a long-day dormant stage like *Allium cepa*, so it continues its vegetative growth and does not develop a real bulb. However, some cultivars which originated from cold temperate areas show short-day dormancy. They stop growing and their leaves dry out and die off under short days, even when the temperature would permit normal growth. The lateral buds in the leaf axils elongate and develop as tillers to form a clump. This tillering characteristic is more pronounced in cultivars grown for the green leaves than in those grown for the long blanched pseudostems.

Flower induction is controlled by temperature and daylength. Low temperatures and short days induce flowering, but requirements vary strongly with the origin of cultivars. Flowering is generally induced by temperatures below 13°C, when seedlings have formed a certain number of leaves or a pseudostem of a certain thickness. In the tropics, where conditions favour vegetative rather than generative growth,

only some well-adapted cultivars will flower.
Roots are readily colonized by arbuscular mycorrhizal fungi, which enhances P uptake and stimulates growth.

Ecology *Allium fistulosum* is adapted to a remarkably wide range of climates. It is very tolerant of cold weather and can overwinter even in Siberia. It is also tolerant of hot humid conditions such as those occurring near Brazzaville and Kinshasa in Central Africa. In Java (Indonesia) it grows well above an altitude of 200 m, but it is more common above 500 m. Most local cultivars are well adapted to variations in rainfall and they are more tolerant of heavy rainfall than other *Allium* spp. Established plants are tolerant of moisture stress and drought will rarely kill them.
A well-drained loamy soil, rich in organic matter is preferred. *Allium fistulosum* is very susceptible to waterlogging, which quickly kills the active roots. For optimal growth a neutral soil pH is required, but even at a pH of 8–10 good growth is possible. In acid soils growth is generally poor.

Propagation and planting In the tropics *Allium fistulosum* is propagated mainly by basal tillers and can be planted the whole year round. Although seed production is possible at elevations above 1000 m, and imported seed of Taiwanese and Japanese cultivars is also available, plants are rarely raised from seed because this is more difficult under tropical conditions and is more time-consuming. However, in the Brazzaville-Kinshasa area, both tillers and seed of local cultivars are used. In temperate areas where seed production is more successful, propagation is mainly by seed, which is either sown directly into the field or first in nurseries. The weight of 1000 seeds is 2.2–2.5 g. Seed requirements are 8–16 kg/ha for direct seeding and 2–4 kg/ha in the case of transplanting. In nursery beds, seeds are either broadcast or sown in rows or in 5–6 cm wide bands. The area of nursery required is 10–12% of the field area. Seedlings are ready for transplanting when 25–30 cm tall and thick as a pencil.

Management For green leaf production, land preparation is light. Tillers or seedlings are transplanted into raised beds or ridges, which are alternated with furrows for irrigation and drainage. Planting distances are about 20 cm × 25 cm (200,000 plants per ha). About one-third of the top part of the tiller is usually trimmed to reduce transpiration. Planting holes are filled with 50–100 g of manure (10–20 t/ha) and the shoots inserted slanting to stimulate tillering. Urea or ammonium sulphate at a rate of 3 g per plant (about 600 kg/ha) is applied 3 weeks after planting, and again at 6 weeks after planting if soil fertility is low. Weeding and earthing up are usually practised 6–7 weeks after planting. *Allium fistulosum* needs plenty of water. At lower elevations, it is usually grown during the rainy season. Daily irrigation is necessary during the dry season. Mixed cropping with white cabbage, carrot and potato is common in the highlands.
For blanched pseudostem production, fields are deeply cultivated. Furrows of 10–20 cm deep are made, the soil being thrown to one side forming a ridge which will support the young plant and facilitate earthing up later. Earthing up is essential to blanch and soften the leaf-sheath cylinder. As earthing up also affects aeration of the roots and thus checks growth, it should be done gradually and not be started too early.

Diseases and pests Although *Allium fistulosum* is generally a healthy crop, it may be affected by a number of diseases, many of them common to most *Allium* crops. Purple blotch (*Alternaria porri*), which causes characteristic concentric spots on the leaves, and downy mildew (*Peronospora destructor*) may cause severe problems. White rot (*Sclerotium cepivorum*) may cause serious losses under successive or repeated cropping, as the pathogen is very persistent in the soil. Poor, unbalanced nutrition and heavy rains stimulate the development of the diseases. The practice of vegetative propagation is conducive to virus infestation, but many landraces seem to be relatively tolerant. Diseased plants should be removed by rigorous visual inspection of the planting material. *Allium fistulosum* is resistant to the onion yellow dwarf virus (OYDV), but susceptible to the welsh onion yellow stripe virus (WoYSV), occurring e.g. in Japan and Indonesia. It causes similar mosaic-type symptoms, including chlorotic mottling, streaking and stunting, and distorted flattening of the leaves. Relative tolerance is found in cultivars of Kujyo Group.
Allium fistulosum is resistant to several diseases affecting other *Allium* spp. including pink root caused by *Pyrenochaeta terrestris*, neck rot caused by *Botrytis* spp. and leaf rot caused by *Botrytis squamosa*. Partial resistance has been found to anthracnose (*Colletotrichum gloeosporioides*).
The beet army worm (*Spodoptera exigua*) and

the American bollworm (*Heliothis armigera*) are the most serious pests. They are difficult to control because the larvae hide inside the hollow leaves and the waxy layer on the leaves hinders wetting. Onion thrips (*Thrips tabaci*) may cause considerable damage. Thrips damage is stimulated by pesticide sprayings against *Spodoptera*, which kill the natural enemies of the thrips. Overhead sprinkling reduces thrips damage.

Harvesting In the tropics *Allium fistulosum* can be harvested year-round; in the Brazzaville-Kinshasa area it is mainly harvested during the rainy season. Plants are pulled out about 2.5 months after planting the tillers. The part used as planting material for the next crop is left in the field until it is needed. Harvesting is a labour-intensive operation, especially for pseudostems, which have to be dug up, cleaned and bundled. Mechanized harvesting equipment has been developed in Japan.

Yield Yield data for countries in Africa are not available. Average yields in Japan and Korea are about 25 t/ha, in Taiwan 10–15 t/ha. In Indonesia, they are considerably lower, averaging 7 t/ha, but they may reach 15 t/ha; however, the growing period is only 2.5–3 months compared to 9 months in East Asian countries.

Handling after harvest After harvesting, leaves and pseudostems are cleaned, dried or damaged leaves are removed, and the plants are bunched and packed in boxes or baskets for transport to the market.

Genetic resources Collections of germplasm are maintained in Japan, the United States, the United Kingdom, Germany and the former Soviet Union. IPGRI ranked *Allium fistulosum* second in importance in the genus *Allium* because of its disease resistance, ecological adaptability and close relationship to *Allium cepa*. Breeders often maintain their own collections and commonly exchange materials, thus maintaining an adequate level of variability.

Breeding In most countries farmers produce their own seed or planting material. In Japan a seed industry has developed, and several new cultivars are released per year. Large breeding programmes also exist in China and Taiwan. Breeders aim at improved cultivar homogeneity and adaptation to specific ecological conditions. For pseudostem cultivars, breeding work aims at obtaining lines with minimal tillering. Male sterile lines exist and F_1 hybrids have been developed.

Prospects The great adaptability of the crop and the example of Japan and Taiwan, where intensification of cultivation combined with selection, breeding and the development of a good marketing network has led to a greatly increased production, indicate that there is great scope for the development of better cultivars and for increased commercialization and intensification of production in the tropics, including Africa.

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Sources of illustration Oyen, L.P.A. & Soenoeadji, 1993.

Authors L.P.A. Oyen & C.-M. Messiaen

ALLIUM SATIVUM L.

Protologue Sp. pl. 1: 297 (1753).
Family Alliaceae
Chromosome number $2n = 16$

Vernacular names Garlic (En). Ail (Fr). Alho (Po). Kitunguu saumu, somu, thumu (Sw).

Origin and geographic distribution Garlic is believed to originate from Central Asia (Kazakhstan, Uzbekistan and western China). This was confirmed by phylogenetic analysis based on molecular and biochemical markers, also indicating a secondary diversity centre in the Caucasus. Garlic spread to the Mediterranean in ancient times. It was already grown in Egypt in 1600 BC and is an ancient crop in India and China as well. At present garlic is grown all over the world from the equator to latitudes of 50° in both hemispheres, but is most popular in China, the Mediterranean and Latin America. In tropical Africa, garlic is grown during the cold season in the Sahel and at high elevations in East and southern Africa. It is a popular crop in the savanna zone, with a

Allium sativum – planted

wide genetic variation in local cultivars. It is rarely, if ever, found in hot and humid lowlands.

Uses After onion, garlic is the second most widely used cultivated *Allium*. The bulb, com posed of so-called cloves, is mainly used for flavouring meat, fish, sauces and salads, raw or cooked, or more recently in dehydrated form. Apart from bulbs, the young floral stems are also used in Spain, China and Indonesia, and whole young green plants are used too. Garlic is much valued as a phyto-therapeutic crop. Garlic users, including many African people, extol its taste and health qualities. Crushed raw garlic is strongly antibiotic, and it has a reputation for lowering blood pressure and cholesterol, and inhibiting thrombus formation. Leaves and bulbs are considered to have hypotensive, carminative, antiseptic, anthelmintic, diaphoretic and expectorant properties. Several attributed prophylactic qualities are questionable, but have resulted in a rich supply of and demand for medicinal pills, drinks and powders based on garlic extracts.

Production and international trade World production for 2001 is estimated by FAO at about 11 million t. China is by far the largest producer with 7.9 million t from 585,000 ha; other important producers are: India (500,000 t), South Korea (486,000 t), United States (336,000 t), Egypt (215,000 t), Russia (202,000 t), Spain (179,000 t), Argentina (130,000 t), Ukraine (127,000 t) and Turkey (103,000 t). Mediterranean North Africa (excluding Egypt) produces 66,000 t, tropical Africa accounted for 29,000 t (mainly Sudan with 17,000 t, Niger 8000 t and Tanzania 2000 t), but most of the West African countries, which are producers at the scale of traditional agriculture and local markets, are not mentioned in statistics. Production areas are found in the Sahel and the highlands of Kenya, Tanzania, Uganda and Zambia, but there are no records on acreages. Production in tropical Africa is not large enough to fulfil local needs; prices in local markets are high and imports are necessary. Principal exporting countries are Spain and Argentina, and more recently China. Occasionally Mexico and Peru export too. The import-export market of garlic fluctuates highly as a result of the prices at which garlic is offered. The United States is an exporter of dehydrated garlic.

Properties The nutritional value per 100 g of peeled cloves (i.e. 79% of the dry bulb weight) is: water 64.3 g, energy 411 kJ (98 kcal), protein 7.9 g, fat 0.6 g, carbohydrate 16.3 g, dietary fibre 4.1 g, Ca 19 mg, P 170 mg, Fe 1.9 mg, carotene trace, thiamin 0.13 mg, riboflavin 0.03 mg, folate 5 µg and ascorbic acid 17 mg (Holland, B., Unwin, I.D. & Buss, D.H., 1991). When used immature, the edible portion amounts to 50–70% of the total plant weight. The flavour of garlic is based on sulphur-containing compounds collectively referred as S-alkyl-cysteine sulphoxides. Garlic is characterized by the predominance of alliin (S-allyl-L-(+)-cysteine sulphoxide), which is odourless, but on crushing breaks down to allicin (diallyldisulphide-mono-S-oxide), the principal element of the taste of raw garlic. Allicin is also instable, especially during cooking, and converts into diallyldisulphide, the principal taste component of cooked garlic.

Several specific medicinal aspects of garlic have been demonstrated. In in-vitro experiments, garlic showed antibacterial and antifungal activity against both gram-positive and gram-negative bacteria (including enteropathogens), pathogenic yeasts (*Candida* spp.) and some skin-pathogenic fungi. In-vivo studies with rabbits and guinea-pigs showed positive results when experimentally induced dermatophyte infections were treated with a garlic extract. Tests with rabbits and rats demonstrated that garlic extract lowers blood cholesterol and triglyceride and also has antihypertensive and antihyperglycaemic effects. The best investigated medicinal property, however, is the effect on platelet aggregation. Garlic extracts show in-vitro activity against platelet aggregation. Clinical tests have been conducted (inhibition of platelet aggregation, lipid-lowering activity),

but the results are conflicting or inconsistent. Regular consumption of garlic is correlated with a reduced risk of stomach cancer. Tests on rats and mice demonstrated anticancer activity of garlic and its major compounds.

Description Erect herb, usually grown as an annual from small bulbs (cloves), up to 150 cm tall; real stem very short, formed at the base of the plant in the form of a disk, with adventitious roots at base; bulb solitary, depressed globose to ovoid, up to 7 cm in diameter, whitish to purplish, composed of (1–)7–15(–40) sessile cloves, these ovoid to ellipsoid-oblong and borne in the axil of the 2, 3 or 4–5 last leaves, each clove consisting of a protective sheath, a single thickened storage leaf sheath and a small central bud; pseudostem formed by sheathing bases of successive leaves. Leaves 4–10, distichously alternate, glabrous, with tubular sheath; blade linear-oblong, up to 50 cm × 2.5 cm, nearly flat or V-shaped in cross-section, acute at apex, smooth or crenulate at margins. Inflorescence a spherical umbel up to 2.5 cm in diameter, on a solid scape up to 150 cm long,

Allium sativum – 1, 2, plant habit; 3, bulb; 4, inflorescence.
Source: PROSEA

initially curved as a crook, then coiled and eventually straight; umbel composed of flowers and bulbils or only bulbils, initially surrounded by a membranous spathe splitting on one side. Flowers usually poorly developed or absent; pedicel slender, up to 1.5 cm long; tepals 6, in 2 whorls, free, lanceolate, up to 3 mm long, greenish white or pale pink; stamens 6, usually rudimentary; ovary superior, 3-celled, style shorter than tepals. Fruit abortive, seedless.

Other botanical information Garlic cultivars can be classified according to morpho-physiological characters into cultivar-groups which are in coincidence with categories delimited with biochemical tests, except in the centre of origin, Central Asia and the Caucasus, where a considerable genetic diversity is hidden under a rather monotonous morphology. Garlic seems to have been spread six or seven times from there to other parts of the world.

A classification of *Allium sativum* into 4 groups has been proposed by Maass & Klaas (1995), based on morpho-physiological characteristics as well as phylogenetic analysis on the basis of biochemical and DNA markers: Sativum Group, Ophioscorodon Group, Longicuspis Group and Subtropical Group. Of these, Longicuspis Group, comprising seed-producing cultivars from Central Asia, is considered the ancestral group from which the other groups evolved. Sativum Group is highly heterogeneous (and often subdivided into up to 5 separate groups) and together with Subtropical Group includes cultivars grown in the tropics. Ophioscorodon Group, also known as rocambole or serpent garlic, is mainly grown in eastern Europe.

Three groups of cultivars belonging to Sativum Group are grown in tropical Africa: the first (distinguished as isozyme type IIa) having white or pale purple bulbs, each with 20–40, small, white or pale pink cloves, erect and narrow leaves, and long and thin pseudostems, cultivated in Egypt and tropical lowlands; the second (tropical ramification of isozyme type IIb) having small bulbs, each with 10–12 small, pink cloves, grown in Senegal, Mali and Niger; and the third (tropical ramification of isozyme type IIc) having white bulbs, each with 8–12 white cloves and comparatively wide leaves, grown in cooler regions where Chinese immigrants are present. The fourth group grown in tropical Africa belongs to Subtropical Group (distinguished as isozyme type Vb); it has purple bulbs, each with 5–10 large cloves, comparatively wide, decumbent leaves, and is

grown in highlands. Cultivars of this group are grown on a large scale in Mexico, Peru and Thailand. The distribution of these 4 groups in Africa seems linked to climatic conditions (lowland/highland) and contingency, except for one group (isozyme type IIb), which is characteristic for West Africa and probably of very ancient origin. Countries with the largest number of cultivars are those with the most heterogeneous human population (e.g. Réunion, where 7 cultivars have been observed).

Growth and development During its life cycle the garlic plant undergoes successive stages of growth and development. The dormancy of mature cloves, induced by temperatures of 25–30°C, is eliminated most quickly at 6–7°C. Vegetative growth is optimal at 18–20°C. When 12–14 leaves have been produced (when the last leaves are present, the first ones have disappeared), bulb swelling is induced at temperatures above 20°C if the day length exceeds a threshold of 12–15 hours, depending on the cultivar, and provided a 'low temperature need' following dormancy elimination has been satisfied. Because of this set of requirements garlic production in the tropics is more difficult than onion production. Fortunately, there is considerable physiological variability amongst garlic cultivars. Those which can be grown under tropical conditions are not strongly dormant, their 'low temperature need' is not very pronounced, and their photoperiodic threshold less than 12 hours. The total growing period varies from 4 months (in the tropics, or strongly dormant cultivars planted in spring in temperate countries) to about 9 months (for less dormant cultivars planted in autumn in northern Mediterranean areas).
Under optimal conditions of latitude and elevation, some garlic cultivars (e.g. those from Central Asia or Spain) regularly produce inflorescences. Only some cultivars from Central Asia and the Caucasus produce well-developed flowers and seeds, provided the bulblets that occur among the floral buds are removed at an early stage. Recently a Mexican clone was discovered which behaves similarly. Other cultivars, even if they produce inflorescences under normal conditions, have flowers which remain seedless. Others do not produce inflorescences under normal conditions, but only if planted at higher elevations or latitudes.

Ecology In the tropics garlic growing is possible in the highlands and is restricted in the lowlands to the cool season. Garlic prefers a light loamy soil. It strongly dislikes soil acidity and requires a soil pH of 6–7 or somewhat higher. It is sensitive to aluminium toxicity.

Propagation and planting Garlic is usually propagated by cloves, very rarely by bulbils from the inflorescence. In most areas in Africa at latitudes of 10–25° garlic is planted at the end of the rainy season. The soil should be deeply tilled before planting. Since bulbs do not grow very large in the tropics, especially in the lowlands, plant density should be fairly high: 40–60 plants/m², or 800–1200 kg/ha planting material of cloves weighing 2 g. The cloves are planted upright at a depth of 5–7 cm. It is good practice to mulch the soil lightly with rice straw immediately after planting.

Management Depending on soil fertility a heavy fertilization is needed, containing sufficient sulphur, e.g. 150 kg/ha of N, 65 kg P and 125 kg K for an expected harvest of 10 t/ha. A suitable fertilizing scheme is a basal dressing of 200 kg/ha of triple superphosphate during soil tillage, and a mixture of 80 kg urea, 80 kg ammonium sulphate and 50 kg potassium chloride per ha as side dressing in 3 split applications at 15, 30 and 45 days after planting. Organic matter must be used in a fully decomposed state, or should be applied to the previous crop. Garlic is very susceptible to soil acidity and aluminium toxicity, conditions which can be improved by application of finely ground limestone (2 t/ha in soils with pH <6) in the planting furrow. If grown during the dry season, garlic has to be irrigated frequently as it is shallow rooted. Furrow irrigation is preferable. Overhead irrigation can be applied during the hot hours between 11 a.m. and 3 p.m., when conditions are unfavourable for *Alternaria porri*. Garlic does not compete well with weeds and should be weeded thoroughly especially when young.

Diseases and pests The most important diseases of garlic are purple leaf blotch (*Alternaria porri*) and pink root (*Pyrenochaeta terrestris*). Leaf blotch is very common when air humidity is high; poor calcium nutrition and aluminium toxicity increase plant susceptibility. It can be controlled by fungicide sprays (e.g. iprodione or dithane), but healthy planting material, a low N gift, and a wider spacing may also reduce the damage. Pink root is a soilborne disease often observed in the Sahel. It is kept under control by crop rotations with 5 years without onion and garlic. The most important diseases under temperate conditions, white rot (*Sclerotium cepivorum*), stem and bulb nematodes (*Ditylenchus dipsaci*) and *Puc-*

cinia rusts, are less problematic in the tropics, their temperature optima being rather low. However, if introduced with contaminated cloves, white rot (optimum temperature 18°C) and, still more often, stem and bulb nematodes (optimum temperature 22°C) can appear at altitudes above 1500 m.

Every garlic cultivar harbours one and more often several viruses, the most noxious of which are the garlic strains of the potyviruses onion yellow dwarf virus (OYDV) and leek yellow stripe virus (LYSV). Their elimination by meristem culture allows a yield increase of 25–50% depending on cultivar and clone. White tip leaf necrosis, often erroneously ascribed to *Botrytis*, is most often non-parasitic and linked with drought and unfavourable soil conditions.

Thrips tabaci is the most widespread pest, inducing a greyish striated discolouration. Thrips can be controlled by insecticides, but spraying water into the leaf-whorls, and even overhead irrigation can limit their development. Army worm (*Spodoptera* spp.) and other caterpillars may damage garlic leaves; however, chemical control of these insects may enhance damage by thrips because their natural enemies are also killed. Garlic leaves are occasionally damaged by the omnivorous grasshopper *Zonocerus variegatus*. During storage, the bulbs can be invaded by the dry bulb mite (*Aceria tulipae*, an eriophyid mite) proliferating between the flesh and the skin of the clove. Dusting bulbs with sulphur can control this pest.

Harvesting Harvesting takes place when the leaves start turning yellow and begin to dry up. This is 100–120 days after planting, depending on cultivar and growing conditions; in highlands garlic may take 150 days to maturity. If the protective bulb coats are not fully dry at harvest, bulbs are dried in the field. To avoid a bluish discoloration they should not be dried under direct sunshine and are therefore windrowed with the leaves covering the bulbs.

Yield Yields are below 5 t/ha in traditional garlic growing in the tropics. By using better planting material and proper fertilization, yields of 8 t/ha in the lowlands and 10 t/ha at higher elevations can be obtained.

Handling after harvest Garlic is packaged in bunches, braids or crates. Deterioration by sprouting and mould invasion (*Penicillium* and *Aspergillus* spp.) occurs quickly at temperatures close to 7°C. In temperate countries bulbs are stored at −2°C but under tropical conditions storage is possible in well ventilated rooms at temperatures of about 27°C. Most cultivars grown in tropical Africa behave well under those conditions.

Genetic resources Important collections of garlic cultivars are maintained at Gatersleben (Germany), Olomouc (Czech Republic), Kagoshima University (Japan), La Consulta, Mendoza (Argentina), Lembang (Indonesia) and at AVRDC (Taiwan). A collection of West African cultivars is maintained in Mali, where they are evaluated. Tropical cultivars are difficult to preserve in temperate regions, maturing too early in spring, and being susceptible to serious frost.

Breeding Selection of improved cultivars from seed produced by Central Asian cultivars is being carried out by several institutes (Japan, United States, Europe, Israel), and may give interesting results for temperate countries (virus resistance and cultivars that can be multiplied by seed). The recent discovery of a fertile Mexican clone might extend this type of research to tropical countries. For the moment, the easiest way for breeding improved cultivars for the tropics is a broad clonal selection in local or imported populations, followed by virus elimination by meristem culture. Such 'regenerated superior clones' may exceed the yield of original heterogeneous and diseased populations by 50–100%. A collection of subtropical and tropical regenerated clones is maintained at INRA, Montfavet, France. One of them, 'Ramses' (of Egyptian origin) is multiplied in France under controlled conditions, and can be grown at a latitude of 15°N (e.g. in Senegal) during the dry season provided nights are not warmer than 15°C during initial growth. Multiplication plots need to be isolated (300 m) from other garlic fields, with a crop rotation of more than 5 years without any *Allium* species, and should be inspected for virus-diseased plants. Even if meristem culture is not possible in local laboratories, the preliminary work of clonal selection could advantageously be done on the spot.

Prospects Garlic is of increasing importance as a commercial crop, liked by consumers because of its taste and phyto-therapeutic properties. The farmers' interest in the crop has grown considerably in recent times. African countries strive to be independent from import. Imported mother bulbs of superior regenerated clones can be multiplied two or three times in tropical countries to reduce the costs of planting material, but if economically feasible it would be better to organize their controlled multiplication in the country itself, preferably

by cooperative associations of growers. An alternative would be to develop improved seed-grown cultivars, although it seems that several problems have to be overcome (e.g. bulblet development in the inflorescence, slow development of plants grown from seeds, heterozygosity). In addition, in Africa seed would have to be imported, but farmers could use it for 1 year and produce subsequent crops vegetatively, until it becomes more economical to buy new seed.

Major references Engeland, R.L., 1991; Etoh, T., Kojima, T. & Matsuzoi, N., 1992; Etoh, T. et al., 1988; Haber-Mignard, D., 1996; Lallemand, J. et al., 1997; Maass, H. & Klaas, M., 1995; Messiaen, C.-M. et al., 1993; Rabinowitch, H. & Brewster, J.L., 1990; Diah Sulistiarini, Juliasri Djamal & Iman Raharjo, 1999; van der Meer, Q.P. & Anggoro H. Permadi, 1993.

Other references Burba, J.L., 1995; Holland, B., Unwin, I.D. & Buss, D.H., 1991; Le Bon, A.M. & Siess, M.H., 2000.

Sources of illustration van der Meer, Q.P. & Anggoro H. Permadi, 1993.

Authors C.-M. Messiaen & A. Rouamba

ALTERNANTHERA LITTORALIS P.Beauv.

Protologue Fl. Oware 2: 72 (1818).

Family Amaranthaceae

Synonyms *Bucholzia maritima* Mart. (1826), *Alternanthera maritima* (Mart.) A.St.-Hil. (1833), *Telanthera maritima* (Mart.) Moq. (1849).

Origin and geographic distribution *Alternanthera littoralis* is recorded in Africa along the Atlantic coast from Senegal to Angola, and from Madagascar. It also occurs along the Atlantic coast of South America.

Uses The leaves of *Alternanthera littoralis* are collected from the wild and eaten as a cooked vegetable by various ethnic groups in Atlantic coastal regions in Africa. Because of its long stolons the plant is also a useful sand-binder. In Côte d'Ivoire it is medicinally used as an alterative for children and pulped up it is applied to frictions to treat oedema.

Properties The leaves of *Alternanthera littoralis* contain per 100 g: water 78.5 g, energy 230 kJ (55 kcal), protein 5.0 g, fat 0.9 g, carbohydrate 10.0 g, fibre 2.2 g, Ca 142 mg, P 35 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968).

Botany Creeping, fleshy herb with stoloniferous, angular, glabrescent stems up to 10 m long, rooting at the nodes. Leaves opposite, simple, fleshy, pubescent; petiole c. 2 mm long; blade oblanceolate to obovate, 3–5 cm × 1.5–3 cm, base attenuate, apex with a small point, margin entire. Inflorescence an axillary, sessile, ovoid head, up to 1.5 cm × 1 cm, usually solitary or in pairs, up to 20-flowered. Flowers bisexual, regular, 5-merous, white; tepals unequal, 2 external ones concave, 6.5 mm long, pubescent and with 3 thick veins, internal ones narrower, 4.5 mm long, glabrous, with only 1 thick vein; stamens 3 mm long, united in lower third, filaments and anthers about equal in length, staminodes alternating with stamens, with 3–5 lobes at apex; ovary superior, subglobular, 1-celled, glabrous, style distinct, with head-like, papillose stigma. Fruit an indehiscent, obovoid capsule with thin wall, 1-seeded. Seed subglobose, c. 1 mm in diameter, glossy brown.

Alternanthera comprises about 200 species, distributed pantropically but most abundantly in tropical America. In tropical Africa about 6 species are found.

Mainly based on the degree of hairiness of leaves and tepals, 4 varieties of *Alternanthera littoralis* have been distinguished, 3 of which occur in Africa. However, delimitations are not sharp.

Ecology *Alternanthera littoralis* grows in coastal sands down to the high-water mark. In Senegal it colonizes the tops of coastal sand dunes and helps to bind them with its long stolons. The plant is a pronounced halophyte; it flowers and fruits year-round.

Genetic resources and breeding *Alternanthera littoralis* is widespread and not in danger of genetic erosion.

Prospects *Alternanthera littoralis* will remain a minor vegetable, which is only locally of importance. Its ability to grow on soils with a high salt concentration combined with its sand-binding properties deserve further research.

Major references Burkill, H.M., 1985; Burkill, H.M., 2000; Leung, W.-T.W., Busson, F. & Jardin, C., 1968.

Other references Bouquet, A. & Debray, M., 1974; Cavaco, A., 1954a; Cavaco, A., 1974; Hauman, L., 1951a; Kerharo, J. & Bouquet, A., 1950; Lemmens, R.H.M.J. & Horsten, S.F.A.J., 1999; Pedersen, T.M., 1990; Raponda-Walker, A. & Sillans, R., 1961.

Authors P.C.M. Jansen

ALTERNANTHERA SESSILIS (L.) DC.

Protologue Cat. pl. horti monsp.: 77 (1813).
Family Amaranthaceae
Chromosome number $2n = 34, 96$

Vernacular names Sessile joyweed, dwarf copperleaf (En). Brède chevrette, magloire (Fr). Periquito-sessil (Po).

Origin and geographic distribution *Alternanthera sessilis* possibly originates from tropical America but is now widespread in the tropics and subtropics of the world, including the whole of tropical Africa.

Uses In many places of the world, the leaves of *Alternanthera sessilis* are eaten as a cooked vegetable or raw as a salad. In tropical Africa its use as a vegetable has been reported from Guinea (where it is used in place of rice as a staple and is said to be satiating), Benin (in sauces and soup), Nigeria (in soup), DR Congo, Tanzania and Zambia (as a relish), as well as from Madagascar and Réunion (as a potherb). In Sri Lanka the plant is tied in bundles and sold on markets for use in salads. It is also exported to Europe for clients of South-Indian origin.

Alternanthera sessilis is used for simple stomach disorders, diarrhoea, dysentery and as a plaster for diseased or wounded skin parts and against fever. In Ghana a decoction with some salt is taken to stop vomiting blood. In Nigeria the pounded plant is used against headache and vertigo, and leaf sap is sniffed up the nose to treat neuralgia. A paste is used to draw out spines or any other object from the body and it is also used to cure hernia. In Senegal and India leafy twigs, ground to a powder, are applied against snakebites. The plant is also used in veterinary medicine in Kenya. *Alternanthera sessilis* is used in local medicine in Taiwan, often in mixtures with other medicinal plants, to treat hepatitis, tight chest, bronchitis, asthma and other lung troubles, to stop bleeding and as a hair tonic. In India it is used as a cholagogue, abortifacient and febrifuge, in Thailand and Sri Lanka as a galactagogue.

Properties The fresh leaves of *Alternanthera sessilis* contain per 100 g: water 80 g, energy 251 kJ (60 kcal), protein 4.7 g, fat 0.8 g, carbohydrate 11.8 g, fibre 2.1 g, Ca 146 mg, P 45 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968).

In *Alternanthera sessilis* the following compounds have been demonstrated to be present: the triterpenes α-spinasterol, β-spinasterol, stigmasterol, β-sitosterol, oleanotic acid and its derivatives and saturated (aliphatic) esters. The leaves contain dietary fibre (about 12 g per 100 g dry matter) and incorporation of about 75 g of this vegetable fibre in the daily diet of diabetics significantly reduced the postprandial blood glucose level.

In tests in India, leaf pastes of *Alternanthera sessilis* exhibited inhibition of mutagenicity in *Salmonella typhimurium* strains. They inhibited the formation of the potent environmental carcinogen nitrosodiethanolamine from its precursors such as triethanolamine. The aqueous alcohol extract of the entire plant exhibits hypothermic and histaminergic activities and relaxes smooth muscles. An ether extract of *Alternanthera sessilis* yielded an active principle having anti-ulcerative properties.

Botany Perennial, sometimes annual herb up to 1 m tall, erect, ascending or creeping, often widely branched, with robust taproot; stem striate, terete below, slightly tetragonous above, solid, sometimes floating in water and fistulose in lower part, stem and branches with narrow lines of whitish hairs and branch and leaf axils with tufts of white hairs. Leaves op

Alternanthera sessilis – 1, plant habit; 2, flower with bract and bracteoles; 3, flower with tepals removed; 4, fruit.
Source: PROSEA

posite, simple; petiole up to 5 mm long; blade linear-lanceolate, oblong to ovate or obovate, 1–15 cm × 0.2–3 cm, glabrous to sparsely pilose. Inflorescence an axillary, sessile, subglobose head 5 mm in diameter, solitary or in clusters of up to 5. Flowers bisexual, regular, 5-merous; tepals free, equal, ovate to elliptical, up to 2.5 mm long, white to pinkish, 1-veined; stamens united at base into a very short cup, 2 without anthers; ovary superior, strongly compressed, 1-celled, style very short. Fruit an obreniform, corky, indehiscent capsule c. 2 mm long, dark brown, 1-seeded. Seed discoid, c. 1 mm long, shiny brown.

Alternanthera comprises about 200 species, distributed pantropically but most abundantly in tropical America. In tropical Africa about 6 species are found.

Alternanthera nodiflora R.Br. (synonym: *Alternanthera sessilis* (L.) DC. var. *nodiflora* (R.Br.) Kuntze), closely related to *Alternanthera sessilis*, originates from Australia, but is also widespread in Africa. Its tepals are 3–4 mm long and its fruits are pale brown to yellow. Its ecological requirements are similar to those of *Alternanthera sessilis*. It is eaten in Tanzania as a vegetable and as a famine food in Nigeria. It is grazed by all stock. Medicinally, it has more or less the same uses as *Alternanthera sessilis*. It showed molluscicidal properties against the freshwater snails *Bulinus* and *Biomphalaria*.

Alternanthera sessilis flowers and fruits throughout the year with most vigorous vegetative growth at the onset of the rainy season and the most vigorous reproductive growth at the end of it. The flowers are self-pollinated and the fruits are dispersed by wind and water.

Ecology *Alternanthera sessilis* is a very common plant of constant or periodically humid, open localities in roadsides, gardens, ditches, swamps, ricefields and tea plantations, on many types of soil, at up to 1800 m altitude. The dark, corky fruits often float in great quantities on the water. In fields (e.g. rice) and along watercourses, *Alternanthera sessilis* can become a noxious aquatic or terrestrial weed. It prefers loamy, alkaline soil, low in exchangeable calcium and rich in total nitrogen.

Management *Alternanthera sessilis* is collected from the wild and not cultivated. It can easily be propagated by seed and by rooted stem parts. The average number of seeds per plant is about 2000.

A leaf-spot disease caused by *Fusarium pallidoroseum* has been described in Nigeria. It may spread to crops in which *Alternanthera sessilis* occurs as a weed, e.g. okra, yams, potatoes, onions and carrots.

Genetic resources and breeding *Alternanthera sessilis* is widespread and not in danger of genetic erosion.

Prospects *Alternanthera sessilis* will remain a vegetable of minor importance. The medicinal properties of this common, always available species, deserve more scientific attention, although in many locations it is considered a noxious weed and focus is on its eradication.

Major references Burkill, H.M., 1985; Lemmens, R.H.M.J. & Horsten, S.F.A.J., 1999; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Townsend, C.C., 1985; van der Zon, A.P.M. & Grubben, G.J.H., 1976.

Other references Aruna Krishnakumar et al., 1991; Burkill, H.M., 2000; Datta, S.C. & Biswas, K.K., 1979; Kerharo, J. & Adam, J.G., 1974; Sreedevi & Chaturvedi, A., 1993; Townsend, C.C., 1988; Watt, J.M. & Breyer-Brandwijk, M.G., 1962.

Sources of illustration Lemmens, R.H.M.J. & Horsten, S.F.A.J., 1999.

Authors P.C.M. Jansen

AMARANTHUS BLITUM L.

Protologue Sp. pl. 2: 990 (1753).

Family Amaranthaceae

Chromosome number $2n = 34$

Synonyms *Amaranthus lividus* L. (1753), *Amaranthus oleraceus* L. (1763).

Vernacular names Amaranth, wild amaranth, pigweed, purple amaranth (En). Amarante sauvage, amarante blette (Fr). Amaranto, bredo (Po). Mchicha (Sw).

Origin and geographic distribution *Amaranthus blitum* is a cosmopolitan weed, spread over the world from the tropics to temperate areas such as Japan and Western Europe, in some areas reported as rather noxious. It probably originates from the Mediterranean region. It has been recorded for many African countries, and probably occurs throughout tropical Africa, from Senegal to Ethiopia, South Africa and the Indian Ocean islands. It is mostly a protected weed in backyards and home gardens, and sometimes produced for sale at the market. It is cultivated in Central Africa (Cameroon) and East Africa (Kenya, Uganda). The cultivated type probably originates from India where it still is an important vegetable. It is a popular home garden vegeta-

Amaranthus blitum – wild

ble in south-eastern Europe, e.g. in Greece where it is used as a substitute for spinach (*Spinacia oleracea* L.) during the hot dry summer months.

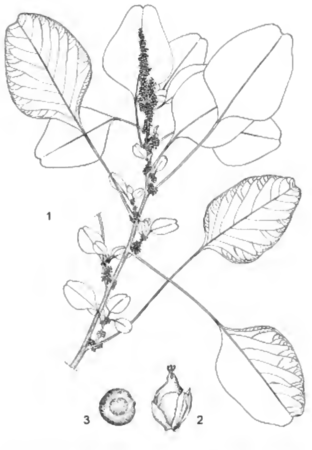
Uses The main use of *Amaranthus blitum* is as a cooked leaf vegetable. In most African countries it is collected as a pot herb from the wild, and is very much liked for its soft taste. Leaves are sometimes preserved by drying. Vegetable amaranths in general are recommended as a good food with medicinal properties for young children, lactating mothers and for patients with fever, haemorrhage, anaemia or kidney complaints. The leaves are used as a febrifuge and poultice to treat inflammations, boils and abscesses. In Nigeria *Amaranthus blitum* is used as a medicine against lung disorders. It is used as fodder but only as a rather moderate part of the daily portion.

Production and international trade *Amaranthus blitum* is important in East Africa as a frequently collected wild plant and a popular vegetable in home gardens. The economic value as a market vegetable is limited, since market growers prefer the more productive *Amaranthus cruentus* L. and *Amaranthus dubius* Mart. ex Thell. No international trade has been reported, but probably it is occasionally imported as a vegetable by Western countries from India or East Africa.

Properties The composition of *Amaranthus blitum* is comparable to that of *Amaranthus cruentus*, samples of the former analyzed in India showing about the same composition. The moisture content and composition show large variations as a function of plant age, ecological conditions and cultural practices such as fertilizing. The composition of *Amaranthus* leaves per 100 g edible portion (89%) is: water 88.9 g, energy 75 kJ (18 kcal), protein 3.5 g, fat 0.3 g, carbohydrate 0.3 g, dietary fibre 2.6 g, Ca 270 mg, Mg 130 mg, P 65 mg, Fe 3.0 mg, carotene 1725 μg, thiamin 0.07 mg, riboflavin 0.22 mg, niacin 0.7 mg, folate 85 μg, ascorbic acid 42 mg (Holland, B., Unwin, I.D. & Buss, D.H., 1991). The dry matter content is high and ranges from 9–22%; the protein content is also high, ranging from 20–38%. The amino acids in the leaf proteins include methionine and other sulphur-containing amino acids. The content of essential micronutrients, especially calcium, iron, carotene, folate and ascorbic acid, is high compared with other leaf vegetables. The calcium is partly insoluble and not taken up in the digestive tract, as it is bound to oxalate. The bioavailability of the iron is 6–12%. The leaves easily become soft after 5–10 minutes cooking in lightly salted water. Some types contain much anthocyane, a brilliant red pigment that dissolves in the cooking water, which is poured off. The leaves and stems contain the antinutrients nitrate (most in the stems) and oxalate at a level similar to other green leaf vegetables such as spinach (*Spinacia oleracea* L.) and spinach beet (*Beta vulgaris* L.). Adverse nutritional effects are not likely where consumption is below 200 g per day. Moreover cooking in ample water removes these toxic components. The rather high content of hydrocyanic acid and oxalic acid makes it less suitable for fresh consumption by humans and is a limiting factor for its use as fodder for animals. *Amaranthus blitum* seed contains linoleic acid.

Adulterations and substitutes In dishes with green leafy vegetables or pot herbs, *Amaranthus blitum* can be replaced by any other vegetable amaranth (*Amaranthus cruentus* is the most important) or several other dark green leafy vegetables.

Description Annual herb, small and stunted to rather tall and erect, up to 100 cm tall; stem simple or branched, glabrous. Leaves arranged spirally, simple without stipules; petiole 1–10 cm long; lamina angular ovate, 1–10 cm × 0.5–6 cm, shortly cuneate at base, notched at apex, entire, glabrous, green or more or less purple, pinnately veined. Inflorescence an axillary many-flowered cluster, forming a false spike at apex of plant, with male and female flowers intermixed; bracts up to 1 mm long. Flowers unisexual, subsessile, with 3(–5) tepals up to 1.5 mm long; male flowers



Amaranthus blitum – 1, flowering and fruiting branch; 2, fruit; 3, seed.
Redrawn and adapted by Iskak Syamsudin

with 3 stamens opposite tepals; female flowers with superior, 1-celled ovary crowned by (2–)3 stigmas. Fruit a subglobular to broadly ovoid-ellipsoid capsule c. 2 mm long, indehiscent or bursting irregularly, crowned by stigmas, 1-seeded. Seed lenticular, up to 1.5 mm in diameter, glossy dark brown to black.

Other botanical information The genus *Amaranthus* comprises about 70 species, including at least 17 species with edible leaves. Many local types and cultivars of *Amaranthus blitum* occur. Cultivated types are larger, more erect and more succulent than weedy types. Mediterranean cultivated types are robust, erect, simple or little-branched plants, up to 1 m tall, with large leaves. The African or Asian (Indian) cultivated types are generally much smaller, up to 50 cm, strongly branched and erect or prostrate. Some cultivated and wild types have dark red inflorescences and a large brown-red spot of anthocyane in the centre of the leaf blade, hence the name 'purple amaranth'. In most African floras the name *Amaranthus lividus* is used instead of *Amaranthus blitum*. The names *Amaranthus blitum* L. and *Amaranthus lividus* L. have been published simultaneously. The correct name depends on the author who first combined the taxa, accepting one of them. J.D. Hooker (1885) seems to be the first to unite them and did so under the name of *Amaranthus blitum*.

Growth and development Emergence of the seedling takes place 3–5 days after sowing. Vegetative development is fast. Like maize and sugar cane, the genus *Amaranthus* is characterized by the C_4-cycle photosynthetic pathway, which means a high rate of photosynthesis at high temperature and radiation. Flowering may start 4–8 weeks after sowing, making the plant less suitable for consumption. Pollination is effected by wind but the abundant pollen production, especially in the flowers in the upper part of the plant, causes a high rate of self-pollination. Insect pollination also takes place. The first seed matures after 2 months. The plants continue growing for several months before dying.

Ecology Vegetable amaranths grow well at day temperatures above 25°C and night temperatures not lower than 15°C. Shade is disadvantageous except in cases of drought stress. Amaranth is a quantitative short-day plant, which is an advantage in the subtropics where the generative stage is retarded during summer. Amaranths like fertile, well-drained soils with a loose structure. The mineral uptake is very high. *Amaranthus blitum* is fairly resistant to adverse climate and soil conditions.

Propagation and planting The seed of *Amaranthus blitum* is larger than the seed of most other *Amaranthus* species with about 1000 seeds/g. In the wild and in home gardens the seed of flowering plants scatters and gives rise to new plants automatically. In the dark, the seed may remain dormant for several years. It germinates when it comes at the surface or in the upper soil layer of less than 3 cm. For market production *Amaranthus blitum* is normally grown as a sole crop on beds. It is also found in intercropping systems with food crops and in home gardens. The common practice in Uganda and in Western Kenya is to sow directly, broadcast or in rows 15–20 cm apart, with a seed rate of 2–5 g/m². The plants are uprooted after 4–5 weeks. Another cultivation method is sowing in a seedbed (nursery) 3–10 g/m² and transplanting after 2–3 weeks. From a nursery, the grower gets up to 1000 plantlets per m² for transplanting. A plant density of 100–200 plants/m² can be used for a once-over harvest whereas 25 plants/m² are appropriate

for repeated cuttings. In Kenya, *Amaranthus blitum* is sown in a mixed cropping with other indigenous vegetables like *Corchorus olitorius* L., in rows 30 cm apart; the seed is mixed with sand for easier sowing.

Management In home gardens, the only care given to *Amaranthus blitum* plants is selective weeding. *Amaranthus blitum* is less fast growing, less susceptible to diseases and pests and more tolerant to drought than the most commonly cultivated amaranth *Amaranthus cruentus*. Because of the rather strong growth of *Amaranthus blitum*, which itself displays a weedy character, weeds are not very troublesome, except sometimes nut grass (*Cyperus rotundus* L.). If rainfall is not sufficient, irrigation by sprinkling should be done before the plants reach their wilting point. Watering every day with 6 mm (6 l/m^2) is sufficient. Water shortage causes early flowering, which reduces the yield and the market quality. Amaranth is a very high consumer of minerals. Only modest crops can be produced on poor soils. The mineral uptake and removal calculated for an *Amaranthus* crop yielding 25 t/ha is 125 kg N, 25 kg P, 250 kg K, 75 kg Ca and 40 kg Mg. Larger quantities of N and K are easily absorbed as luxury uptake if these elements are abundant. Amaranth responds to high rates of organic fertilizer. On poor soils, the application of 400 kg/ha of NPK 10–10–20 in addition to 25 t of organic manure is recommended. A split application is recommended during the rainy season. Nitrate-N is better than ammonium-N. Amaranth does not seem to need to be rotated with other crops since no serious soilborne disease has been observed.

Diseases and pests Stemrot caused by the fungus *Choanephora cucurbitarum* is the main disease. It is favoured by wet conditions, poor soil fertility and high nitrogen doses. Chemical control by repeated spraying with fungicides such as maneb or carbatene reduces the losses, but is seldom applied. Damping-off caused by *Pythium* and *Rhizoctonia* may be serious in seedbeds. It is controlled by good drainage. Over-dense sowing should be avoided. Fungicides such as dithiocarbamates have some effect. No damage by virus diseases has been reported. *Amaranthus blitum* is a natural host for turnip mosaic virus and tobacco leaf curl virus.

Insects are a serious problem for amaranth growers. Caterpillars (*Hymenia recurvalis*, *Spodoptera litura*, *Helicoverpa armigera*) and sometimes grasshoppers are the most harmful. The larvae of the stem borer *Lixus truncatulus* may cause much damage, sometimes already in the seedbed. The basal part of the plant containing the pupae swells and the plant growth is much retarded. Many other insects such as aphids, leafminers, stinkbugs, mole crickets and mites also attack amaranth but generally cause only minor damage. Commercial growers spray insecticides to dispel insects instead of the traditional control method of spreading wood ash.

Amaranth is not very susceptible to nematode damage.

Harvesting Commercial growers harvest by uprooting or by cutting at ground level. If the crop was sown directly, the once-over harvest by uprooting or by cutting at ground level may be done 3–4 weeks after sowing. Some growers obtain a second harvest 3 weeks later from the regrowth of the smallest plants. When harvest is by repeated cutting, the first cutting takes place about 3 weeks after transplanting, and then every 2–3 weeks for a period of one or two months. Cutting should be done at a height that leaves at least 2 leaves and buds for regrowth. The height of the first cutting is normally 10–15 cm.

Yield An uprooted crop of *Amaranthus blitum* may yield 1.0 kg/m^2 at 4 weeks after sowing. A yield of 1.5 kg/m^2 may be obtained from 2–3 cuttings in 2 months from transplanting date. In an experiment in India, 20 t/ha of foliage was obtained 36 days after planting. The yield of *Amaranthus blitum* is definitely lower than that of *Amaranthus cruentus* or *Amaranthus dubius*.

Handling after harvest Harvested plants or shoots are bundled, the roots are washed, and the produce is packed for transport to the market. In markets and shops, it is sprinkled with water to keep a fresh appearance. If uprooted, the vegetable can be kept fresh for some days by putting it in a basin with the roots in the water. It is sold in bunches or by weight. Some people dry the leaves for use during the dry season.

Genetic resources *Amaranthus blitum* is present in Indian collections at the National Bureau of Plant Genetic Resources (NBPGR), New Delhi (India). Some research institutes in East and southern Africa have small working collections of local cultivars, e.g. Kawanda Agricultural Research Institute, Uganda. Evaluation and variability studies are needed to reveal the amount of exploitable genetic variation.

Breeding Breeding of *Amaranthus blitum* as a leafy vegetable has not been reported.

Prospects Although perhaps best known as a weed, *Amaranthus blitum* is recognized as an easy-to-grow, productive, tasty and nutritious vegetable. Research should focus on optimization of cultural practices (integrated pest management to avoid pesticide residues, plant nutrition) and on breeding for a better plant habit and a higher yield.

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Other references Holland, B., Unwin, I.D. & Buss, D.H., 1991; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Pal, M. & Khoshoo, T.N., 1973; Senft, J.P., Kauffman, C.S. & Bailey, N.N., 1981.

Sources of illustration Stevels, J.M.C., 1990.

Authors G.J.H. Grubben

AMARANTHUS CRUENTUS L.

Protologue Syst. nat. ed. 10, 2: 1269 (1759).
Family Amaranthaceae
Chromosome number $2n = 32, 34$

Synonyms *Amaranthus paniculatus* L. (1763), *Amaranthus sanguineus* L. (1763, pro parte), *Amaranthus hybridus* L. subsp. *cruentus* (L.) Thell. var. *paniculatus* (L.) Thell. (1912).

Vernacular names Amaranth, African spinach, Indian spinach (En). Amarante, brède de Malabar (Fr). Amaranto, bredo (Po). Mchicha (Sw).

Origin and geographic distribution As early as 6000 years ago *Amaranthus cruentus* was domesticated as a pseudo-cereal (grain amaranth) in Central America from the weed *Amaranthus hybridus* L. Escaped plants from cultivation also occur in the wild. The vegetable form of *Amaranthus cruentus* was probably introduced in the tropics and subtropics of the Old World during colonial times. At present *Amaranthus cruentus* is a widespread traditional vegetable in all countries of tropical Africa. It is the main leafy vegetable in Benin, Togo and Sierra Leone, and very important in many lowland areas e.g. in southern Nigeria, DR Congo, Kenya and Tanzania. It is more

Amaranthus cruentus – wild and planted

popular in humid lowland than in highland or arid areas. It is also an important vegetable in many tropical areas outside Africa e.g. in India, Bangladesh, Sri Lanka and the Caribbean. The Bangladesh type has big fleshy stems, which are consumed with the leaves. *Amaranthus cruentus* is grown as leaf vegetable throughout South-East Asia, although to a lesser extent than *Amaranthus tricolor* L. In Indonesia it is grown in mountain areas, where the climate is too cold for the more common *Amaranthus tricolor*. Grain amaranth, a cultivar-group of *Amaranthus cruentus* with yellowish white or pale brown seed, is traditionally grown as a cereal crop in Latin America (e.g. Mexico, Guatemala, Ecuador, Colombia). Since colonial times, it has been successfully introduced as a pseudo-cereal in India and Nepal, in mountain areas as well as at lower elevation, and it has become well established as a popular food plant. Thinnings of young seedlings of the grain crop are frequently used as a vegetable. Grain amaranth is produced commercially in hot and dry areas of the United States, Argentina and China. Apart from some try-outs in Zimbabwe, Kenya, Uganda and Ethiopia, grain amaranth is not cultivated in Africa. Ornamental types of *Amaranthus cruentus* characterized by big bright-red inflorescences can be frequently found in tropical and subtropical countries.

Uses The main use of *Amaranthus cruentus* is as a leaf vegetable (vegetable amaranth) prepared by cooking and consumed as a vegetable dish or as an ingredient in sauces. The leaves and tender stems are cut and cooked or sometimes fried in oil, and mixed with e.g.

meat, fish, cucurbit seeds, groundnut and palm oil. Dishes with amaranth are eaten with the main dish of cereals or tubers. Traditionally in arid regions, the leaves are dried and the leaf powder is used in sauces during the dry season. Experimental work in India and the United States has shown that *Amaranthus cruentus* is suitable for the processing of leaf protein concentrates, but as far as is known there is no practical application. In colonial times, amaranth was often recommended to Europeans as the best substitute for spinach (*Spinacia oleracea* L.). In South Africa *Amaranthus cruentus* is grown commercially for canning and sold in supermarkets.

In Nigeria and Zimbabwe, the introduction of whitish-seeded *Amaranthus cruentus* cultivars from America as grain amaranth for the improvement of the diet has not been successful. Some people, e.g. in the savanna zone of northern Nigeria, have started to grow the newly introduced seed forms for the leaves.

Forms with large bright red inflorescences are widely grown as ornamentals. A red dye can be obtained from the inflorescences. *Amaranthus cruentus* is sometimes used as fodder, but only as a moderate part of the daily portion since this use is limited by the high calcium oxalate content. In Benin the dried plants are burned for the preparation of potash. Medicinal uses are manifold. Vegetable amaranths are recommended as a good food with medicinal properties for young children, lactating mothers and for patients with constipation, fever, haemorrhage, anaemia or kidney complaints. Amaranth is rather diuretic. In Senegal the roots are boiled with honey as a laxative for infants. In Ghana the water of macerated plants is used as a wash to treat pains in the limbs. In Ethiopia *Amaranthus cruentus* is used as a tapeworm-expellent. In Sudan the ash from the stems is used as a wound dressing. In Gabon heated leaves were used on tumours.

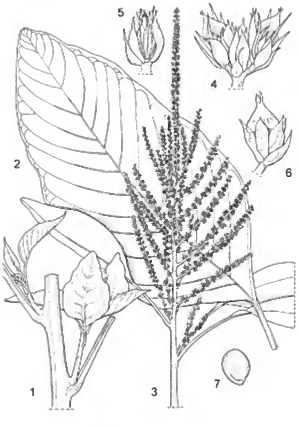
Production and international trade The economic value of *Amaranthus cruentus* as a popular market vegetable ranks high. From market surveys it appears as one of the main African leafy vegetables, possibly the number one in quantity and area. No statistical data are available, since in most cases all leaf vegetables are recorded as one single group. In national or FAO statistics they are not recorded at all. Correct registration is hampered by the short growing period (3–6 weeks), scattered occurrence of small plots of cultivation, and the dispersed sales in small street markets. In the big cities in Benin the average quantity of fresh leafy vegetables bought daily at the markets was 42 g/head/day, 31% of which was *Amaranthus cruentus*. There is some unregistered export of amaranth from African countries, as well as from Latin America (Caribbean, Suriname) to Western Europe.

Properties Amaranth leaves have a high content of essential micronutrients. The dry matter content is high (9–22%). The average composition of *Amaranthus* (probably mainly *Amaranthus cruentus*) per 100 g edible portion is (averages of about 40 samples): water 84.0 g (78.4–91.3), energy 176 kJ (42 kcal), protein 4.6 g (3.2–6.0), fat 0.2 g (trace–0.6), carbohydrate 8.3 g, fibre 1.8 g (0.4–6.4), Ca 410 mg (69–833), P 103 mg (54–230), Fe 8.9 mg (0.6–10.2), β-carotene 5716 μg, thiamin 0.05 mg (0.05–0.06), riboflavin 0.42 mg (0.36–0.44), niacin 1.2 mg, ascorbic acid 64 mg (52–200) (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). Other analyses indicate that amaranth leaves contain 85 μg folate and 1725 μg carotene per 100 g edible portion. The large variation in moisture content and composition is caused more by variations in plant age and ecological and cultural conditions than by species or cultivar. Compared to other leafy vegetables, amaranth is remarkably rich in vitamin A, vitamin C, iron, calcium and folate. However, the absorption of β-carotene and iron by the human body may be rather low, depending on the quality of the fresh product (age, fertilizer use), the preparation method, the combination with other foods and the physical condition of the consumer. The protein has a high content of sulphur-containing amino acids (methionine, lysine, cysteine), which makes it a good combination with cereals. The leaves easily become soft after 5–10 minutes cooking in lightly salted water. It is not common to add potash. The leaves and stems contain nitrate, mostly in the stems, and also oxalate at a level similar to that of several other green leaf vegetables such as spinach (*Spinacia oleracea* L.) and spinach beet (*Beta vulgaris* L.). No adverse nutritional effects occur with a consumption of 100–200 g per day. Moreover, most people cook amaranth in ample water and discard the cooking water containing soluble nitrate and oxalate. A disadvantage of the removal of the cooking water is that water-soluble compounds, especially niacin, riboflavin and thiamin are partly lost. The presence of a rather high content of hydrocyanic acid and oxalic acid makes it less suit-

able for fresh consumption by humans and as fodder. Their content varies greatly with the cultivar, soil fertility, fertilizer dosage, water supply, and age at harvest. The higher the soil fertility (N, P, K, Ca, etc.), the better the yield and the nutritional composition (especially iron, β-carotene and ascorbic acid). However, excessive N fertilizing may result in an unacceptably high nitrate level.
The composition of grain amaranth per 100 g dry matter (87.7% of the edible portion) is: energy 2006 kJ (479 kcal), protein 14.7 g, fat 8.2 g, carbohydrate 74.2 g, fibre 7.6 g, Ca 282 mg, Fe 3.8 mg, thiamin 0.16 mg, riboflavin 0.36 mg, niacin 1.1 mg, ascorbic acid 0 mg (Leung, W.-T.W., Butrum, R.R. & Chang, F.H., 1972). In Western countries amaranth seed is recommended as a health food. The protein quality is excellent because of the high lysine content (3.2–18%). The oil has antioxidant properties. The starch consists mainly of amylopectin. The very small starch granules make grain amaranth an attractive raw material for industrial uses. The significant amount of squalene (4–11% of the oil portion) means that grain amaranth may find a market niche for industrial production of products such as lubricants in the computer industry and in cosmetics and health foods. The red types contain the red colour amaranthin (α-cyanin).

Adulterations and substitutes In many dishes where *Amaranthus cruentus* is used as a green leafy vegetable or pot herb, other amaranth species or other dark green leaf vegetables can be used as a substitute.

Description Annual herb, erect or less commonly ascending, up to 2 m tall, often reddish tinted throughout; stems stout, branched, angular, glabrous or thinly to moderately furnished with multicellular hairs. Leaves arranged spirally, simple, without stipules, long-petiolate; lamina broadly lanceolate to rhombic-ovate, 2–18 cm × 2–15 cm, attenuate or shortly cuneate at base, obtuse to subacute at apex, mucronate, entire, glabrous to sparsely pilose, pinnately veined. Inflorescence large and complex, consisting of numerous agglomerated cymes arranged in axillary and terminal racemes and spikes, the terminal one up to 45 cm long, usually with many lateral, perpendicular, thin branches; bracts 2–3 mm long, with a long awn. Flowers unisexual, subsessile, with 5 tepals 1–2 mm long; male flowers with 5 stamens c. 1 mm long; female flowers with superior, 1-celled ovary crowned by 3 stigmas. Fruit an obovoid to rhombic capsule 2–2.5 mm long, circumscissile, almost smooth, with a short beak, 1-seeded. Seed obovoid to ellipsoid, compressed, c. 1 mm long, whitish to yellowish or blackish. Seedling with epigeal germination; hypocotyl 10–12 mm long; cotyledons c. 1.5 cm long, fleshy, petiolate.



Amaranthus cruentus – 1, part of branch with axillary shoots; 2, leaf; 3, inflorescence; 4, cyme; 5, male flower (one tepal removed); 6, fruit; 7, seed.
Source: PROSEA

Other botanical information *Amaranthus* comprises about 70 species, of which about 40 are native to the Americas. It includes at least 17 species with edible leaves and 3 grain amaranths. *Amaranthus cruentus* belongs to both categories.
Amaranthus cruentus is part of the so-called *Amaranthus hybridus* aggregate, a group of species in which taxonomic problems are far from clarified, especially because of apparently common hybridization and nomenclatural disorder caused by names being commonly misapplied. Some recognized species of this aggregate are cultivated taxa. *Amaranthus cruentus* is one of these, as are the other grain amaranths, *Amaranthus caudatus* L. and *Amaranthus hypochondriacus* L. In fact, a classification in cultivar-groups might be more appro-

priate for these cultivated taxa.
Amaranthus cruentus seems also closely related to *Amaranthus hybridus*, a weed that is the putative progenitor of *Amaranthus cruentus*. Transitional forms between these 4 species can be found. *Amaranthus cruentus* sometimes escapes from cultivation in ruderal localities.
There are many local cultivars of *Amaranthus cruentus* propagated and sold as commercial seed. These cultivars are distinguished by plant habit, leaf form and colour, leaf/stem ratio, growing vigour, resistance to fungal diseases, susceptibility to insect attack, drought resistance, photosensitivity, succulence and taste. In some places in East and southern Africa, yellow-seeded grain types introduced from America have mixed and sometimes hybridized with black-seeded vegetable types.

Growth and development In cool or dark conditions seed remains dormant. Light and high temperatures break the dormancy. In moist soil above 15°C emergence takes place within 3–5 days after sowing. Vegetative development is fast. Like maize and sugar cane, the genus *Amaranthus* is characterized by the C_4-cycle photosynthetic pathway, giving it a high rate of photosynthesis and excellent water use efficiency at high temperatures and radiation intensity. Yet, because of rapid growth, the water consumption is high. A crop with a closed leaf canopy uses about 6 mm/day.
Depending on cultivar, day length and cultural practices, flowering may start 4–8 weeks after sowing, making the plant less suitable for consumption. There are at least four times as many female flowers as male flowers. Pollination is effected by wind, but the abundant pollen production causes a high rate of self-pollination. Some pollination is also effected by insects (bees, flies) and up to 40% outcrossing may occur. Seeds mature after 3–5 months and then the plant dies.

Ecology Vegetable amaranths grow well at day temperatures above 25°C and night temperatures not lower than 15°C, but *Amaranthus cruentus* is grown up to 2000 m altitude in Indonesia. Shade is disadvantageous except in cases of drought stress. Amaranth is a quantitative short-day plant, which is an advantage in the subtropics where the generative stage is retarded during summer. Amaranths like fertile, well-drained soils with a loose structure. The mineral uptake is very high. Although *Amaranthus cruentus* is fairly tolerant of adverse climate and soil conditions, escapes growing as a weed tend to disappear because they cannot compete with true weeds like *Amaranthus spinosus* L. or *Amaranthus hybridus*.

Propagation and planting Vegetable amaranth is usually grown commercially as a sole crop on beds. It is also found in intercropping systems with food crops and in home gardens. There are 2500–3500 seeds/g. The common cultivation practice is sowing in a nursery at a seed rate of 3–10 g/m² and transplanting after 2–3 weeks. In this way the grower gets 1000–1500 plantlets per m² for transplanting. A plant density of up to 180 plants/m² is often practised for harvesting by uprooting or once-over cutting and gives the highest yield. Higher densities result in self-thinning without yield increase. Field experiments in several countries have shown the advantage of a wider spacing, with about 100 plants/m², the yield being only slightly lower but the labour requirement for transplanting much lower. During the rainy season very dense planting is applied as a buffer to compensate for heavy plant losses caused by *Choanephora* stem rot. For repeated cuttings a density of about 20 plants/m² is appropriate. It is also possible to sow directly, either broadcast or in rows with at least 20 cm between the rows, with a seed rate of 2–5 g/m². Direct sowing is the common practice in Nigeria, Uganda and in western Kenya. The plants are uprooted after 3–5 weeks. The main advantage is the lower labour costs; however, this method requires more seed, weed competition is more severe and the yield much lower. At harvest, some vigorous plants are left for seed production. For commercial seed production, a distance of 200 m from other *Amaranthus cruentus* fields is recommended and weedy *Amaranthus cruentus* or *Amaranthus hybridus* plants should be removed to avoid outcrossing or mixtures.
Grain amaranths are sown directly and thinned to a spacing of not more than 10 plants/m².

Management Because of the strong growth of amaranth, weeds are not very troublesome, except nut grass (*Cyperus rotundus* L.) and weeding is usually not necessary. If rainfall is not sufficient, irrigation by sprinkling should be done before the plants reach their wilting point. Watering every day with 8 mm (8 l/m²) is generally sufficient. Water shortage causes early flowering, which reduces the yield and the market quality. Amaranth is a very high consumer of minerals. On poor soils only modest crops can be grown. The mineral uptake and removal calculated for a crop yielding 25

t/ha is: 125 kg N, 25 kg P, 250 kg K, 75 kg Ca and 40 kg Mg. Larger quantities of N and K are easily absorbed as luxury uptake of these elements is abundant. Much N stimulates vegetative growth and retards flowering. Amaranth responds to high rates of organic fertilizer. In some places it is grown on large quantities (up to 50 t/ha) of almost fresh town refuse, which fulfils its need for minerals. On poor soils, the application of 400 kg/ha of NPK 10–10–20 in addition to 25 t of organic manure is recommended. A split application is recommended during the rainy season. Nitrate-N is better than ammonium-N. Amaranth does not seem to need to be rotated with other crops since no serious soilborne diseases have been observed. Many growers cultivate amaranth continuously on the same beds.

Diseases and pests Wet rot or stemrot caused by the fungus *Choanephora cucurbitarum* is the main disease. It is favoured by wet conditions, poor soil fertility and high nitrogen doses. Spraying with fungicides such as maneb or carbatene reduces the losses, but is seldom applied. Damping-off caused by *Pythium aphanidermatum* and *Rhizoctonia* is often serious in seedbeds. It is controlled by good drainage. Over-dense sowing should be avoided. *Pythium* also attacks older plants. Fungicides such as dithiocarbamates have some effect. Local cultivars show large variation in susceptibility to *Choanephora* and *Pythium*. White rust caused by *Albugo candida* is reported as a minor problem. *Alternaria* leaf spot has been reported from Tanzania. No virus diseases have been reported.

Insects are a serious problem for amaranth growers. Caterpillars (*Spodoptera litura*, *Helicoverpa armigera*, *Hymenia recurvalis*) and sometimes grasshoppers are the most harmful. The larvae of the stem borer *Lixus truncatulus* often cause serious damage, sometimes already in the seedbed. The basal part of the plant containing the pupae swells and plant growth is much retarded. Many other insects such as aphids, leafminers, stinkbugs, mole crickets and mites also attack amaranth but generally cause only minor damage. Many commercial growers now spray with insecticides regularly, up to twice a week, instead of using the traditional control method of spreading wood ash to dispel insects. In order to avoid harmful residues, the use of less toxic chemicals is strongly recommended. Biological insecticides derived from *Bacillus thuringiensis* (Bt) are fairly effective against caterpillars. Amaranth is hardly or not susceptible to nematode damage. Penetrating larvae do not develop further. Moreover, harvesting by uprooting removes *Meloidogyne* larvae that have penetrated the roots, making the soil more suitable for a next crop of lettuce, okra, African nightshades (*Solanum* species), *Corchorus* or other vegetables susceptible to root-knot nematodes.

Harvesting The optimal harvest period is reached when the total leaf area is 7 times the ground area (LAI = 7). In practice harvesting is done at a younger stage to obtain a more tender product. Most commercial amaranth growers harvest the whole crop by uprooting 20–30 days after transplanting. Some growers harvest by cutting at ground level. If wide spacing is practised, the harvest method is by repeated cuttings, the first cutting about one month after transplanting, and then every 2–3 weeks for a period of one to two months. Cutting is done at a height which leaves at least 2 leaves and buds behind for regrowth. The height of the first cut is normally 10–15 cm. Low cutting retards bolting. Up to 10 cuttings may be obtained at two-weekly intervals. If the crop was sown directly, the once-over harvest by uprooting or by cutting at ground level may be done 3–4 weeks after sowing. Some growers obtain a second harvest three weeks later from the regrowth of the smallest plants.

Grain amaranths, if grown on a small scale, are harvested by cutting the seed heads early in the morning to avoid scattering.

Yield Good growers normally harvest 2–2.5 kg/m^2 (maximum 3.0 kg/m^2) of an uprooted crop (dry matter content 16%, edible portion 35–50%, being the total of leaves and young stems). The first cutting of a ratooned crop yields 1.0–1.5 kg/m^2 (edible portion 70–80%), the following cutting 0.5–1.0 kg/m^2. Continuous cropping of amaranth may yield up to 30 kg/m^2 marketable product per year. With a land use of 70%, an annual yield of 210 t/ha of marketable product may be obtained. The seed yield of vegetable amaranths is up to 2 t/ha, of grain types up to 5 t/ha. Forage yields of 30 t/ha (with 18% dry matter content) in 8 weeks have been reported, representing a yield of 1.6 t/ha of pure leaf protein of excellent quality.

Handling after harvest The harvested plants are bundled, the roots are washed and the produce is packed for transport to the market. In markets and shops it is sprinkled with water to keep a fresh appearance. If uprooted, the vegetable can be kept fresh for some days by putting it in a basin with the roots in the

water. It is sold in bunches or by weight. The harvested product can be dried in the sun for the preparation of leaf powder. Dry inflorescences harvested for the seed are threshed by putting them in big jute bags and beating with sticks. The bulk of the straw is removed first and then the finer chaff is winnowed.

Genetic resources A collection of amaranths is kept at the Rodale Organic Gardening and Farming Research Center (OGFRC) at Kutztown, Pennsylvania, United States; South-East Asian accessions are kept at the Asian Vegetable Research and Development Center (AVRDC) at Tainan, Taiwan. African cultivars and introductions from OGFRC are kept at the National Horticultural Research Institute (NHR) in Nigeria and African cultivars at the AVRDC centre at Arusha, Tanzania. Indian collections are kept at the National Bureau of Plant Genetic Resources (NBPGR), New Delhi (India). Many national institutes have small working collections of local cultivars. Evaluation and variability studies are needed to reveal the amount of exploitable genetic variation.

Breeding Breeding of *Amaranthus cruentus* as a leafy vegetable has been limited to selection of local cultivars. In some countries (Benin, Nigeria) selections have been made from landraces. A popular and productive cultivar is 'Fotete' in Benin. Experimental breeding of grain types in India shows that there are possibilities for improvement by hybridization. A lot of breeding work has been performed on grain types in the United States and India.

Prospects *Amaranthus cruentus* is recognized as an easy-to-grow and extremely productive and nutritious vegetable. It is probably the highest-yielding leaf vegetable of the tropics. It has high potential for the production of leaf protein concentrates. Its excellent nutritional value makes it an important vegetable for human nutrition, both in rural areas for home consumption and as a cheap green vegetable in city markets. Research should focus on the optimization of cultural practices (integrated pest management to avoid pesticide residues, plant nutrition) and on breeding for fungus and insect resistance. Grain amaranth, however, does not have much future in Africa, since it cannot compete with more productive traditional cereals that are easier to grow. Ornamental types of *Amaranthus cruentus* will probably remain popular garden plants, without much commercial interest.

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Sources of illustration Jain, S.K. & Sutarno, H., 1996.

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AMARANTHUS DUBIUS Mart. ex Thell.

Protologue Fl. adv. Montpellier: 203 (1912).
Family Amaranthaceae
Chromosome number $2n = 64$
Synonyms *Amaranthus tristis* auct. non L.

Vernacular names Amaranth, pigweed (En). Amarante, brède de Malabar (Fr). Amaranto, bredo (Po). Mchicha (Sw).

Origin and geographic distribution *Amaranthus dubius* is a weedy plant widespread throughout the humid lowland tropics. It originates from tropical America, where it is common in the Caribbean region and from southern Mexico to northern South America. The

Amaranthus dubius – wild and planted

cultivated type may have been developed from the weedy ancestor in tropical Asia (Indonesia, India) and is found in several African and Central American countries, where immigrants have introduced it. *Amaranthus dubius* is a protected weed used as a pot herb in many African countries, and it possibly occurs in all African lowland areas. It is a cultivated vegetable in West Africa (Sierra Leone, Ghana, Benin, Nigeria), Central Africa (Cameroon, Democratic Republic of Congo), and East Africa (Kenya, Uganda), but is much less common than *Amaranthus cruentus* L.

Uses The main use of *Amaranthus dubius* is as a cooked leaf vegetable. The product is dark green and tender but its taste somewhat neutral. In Kenya it is cooked with bitter leaf vegetables such as nightshades (*Solanum* spp.), *Cleome gynandra* L. or *Launaea cornuta* (Hochst. ex Oliv. & Hiern) C.Jeffrey to make it more palatable. The leaves easily become soft after 5–10 minutes cooking in lightly salted water. It is not common to add potash. Amaranth leaves in general are recommended as a good food with medicinal properties for young children, lactating mothers and for patients with fever, haemorrhage, anaemia, constipation or kidney complaints. In Tanzania the whole plant is used as a medicine against stomachache. In Uganda *Amaranthus dubius* plants are used for the preparation of potash.

Production and international trade *Amaranthus dubius* is a subsistence vegetable and a collected pot herb, seldom found in markets, but in Kenya it is grown on a commercial scale and sold in city markets. No statistical data on production are available. Commercial growers prefer the more productive *Amaranthus cruentus*. No international trade has been reported, but *Amaranthus dubius* of the local type 'Klaroen' is exported from Suriname to the Netherlands.

Properties The composition of *Amaranthus dubius* leaves is comparable to *Amaranthus cruentus* and other amaranth leaves. The average composition of amaranth leaves per 100 g edible portion is: water 84.0 g, energy 176 kJ (42 kcal), protein 4.6 g, fat 0.2 g, carbohydrate 8.3 g, fibre 1.8 g, Ca 410 mg, P 103 mg, Fe 8.9 mg, β-carotene 5716 μg, thiamin 0.05 mg, riboflavin 0.42 mg, niacin 1.2 mg, ascorbic acid 64 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). The leaves and stems contain nitrate, mostly in the stems, and also oxalate at a level comparable to other green leaf vegetables. Most people cook amaranth in ample water and discard the cooking water containing soluble nitrate and oxalate. The presence of a rather high content of hydrocyanic acid and oxalic acid makes amaranth less suitable for fresh consumption by humans and as fodder for animals.

Adulterations and substitutes *Amaranthus dubius* can be substituted by other amaranths or other dark green leaf vegetables.

Description Erect annual herb, up to 150 cm tall; stems slender to stout, branched, glabrous or upwards, especially in the inflorescence, with short to rather long hairs. Leaves arranged spirally, simple, without stipules; petiole up to 8.5(–12) cm long; lamina ovate or rhomboid-ovate, 1.5–12(–22) cm × 0.7–8(–14) cm, cuneate at the base, blunt or retuse at apex, mucronate, entire, glabrous or shortly pilose, sometimes the centre of the lamina blotched red. Inflorescence spikelike or paniculate, axillary and terminal, the terminal one up to 25 cm long, consisting of glomerules more or

Amaranthus dubius – 1, flowering and fruiting branch; 2, fruit; 3, seed.
Redrawn and adapted by Iskak Syamsudin

less isolated at base of inflorescence and agglomerated towards apex; bracts up to 2.5 mm long, awned. Flowers unisexual, subsessile, with (4–)5 tepals up to 2.5 mm long; male flowers usually near apex of inflorescences, with 5 stamens c. 2 mm long; female flowers with superior, 1-celled ovary crowned by 3 stigmas. Fruit an ovoid-urceolate capsule c. 1.5 mm long, with a short inflated beak below the stigmas, dehiscing circularly, the lid strongly rugulose below the beak, 1-seeded. Seed lenticular, compressed, c. 1 mm long, black.

Other botanical information *Amaranthus* comprises about 70 species, of which about 40 are native to the Americas. It includes at least 17 species with edible leaves. *Amaranthus dubius* is the only known tetraploid *Amaranthus* species ($2n = 64$). It has been postulated as an allotetraploid, with *Amaranthus spinosus* L. as one of the parents and *Amaranthus quitensis* Humb., Bonpl. & Kunth or *Amaranthus hybridus* L. as the other. This theory is disputable because of the different chromosome number of *Amaranthus spinosus* ($2n = 34$). Also, a DNA analysis of the various genomes could not confirm *Amaranthus spinosus* and *Amaranthus hybridus* as ancestors of *Amaranthus dubius*. It is almost impossible to make a distinction between *Amaranthus dubius* and *Amaranthus spinosus* based on morphological characters; *Amaranthus spinosus* has axillary spines which are not present in *Amaranthus dubius*. However, spineless *Amaranthus spinosus* plants with $2n = 34$ have been observed in several localities. In Nigeria an *Amaranthus dubius* plant with $2n = 32$ has been recorded; this might be a spineless *Amaranthus spinosus*. Other more or less reliable differences are the greater number of terminal male flowers in the inflorescences of *Amaranthus spinosus* and the smaller pores of the pollen. Spontaneous hybrids between *Amaranthus dubius* and *Amaranthus blitum* L. mostly with $2n = 32$ have been reported from India and America.

Weedy *Amaranthus dubius* is a small prostrate plant found in open places on wasteland. Cultivated types of *Amaranthus dubius* differ greatly from weedy types; the plants are larger, more erect and more succulent. Several local types and cultivars occur.

Growth and development Emergence of the seedling takes place 3–5 days after sowing. The vegetative development is fast. Like maize and sugar cane, the genus *Amaranthus* is characterized by the C_4-cycle photosynthetic pathway, which means a high rate of photosynthesis at high temperature and radiation. Flowering may start 4–8 weeks after sowing. The plants continue to produce new shoots when older branches are already blooming. Pollination is effected by wind but the abundant pollen production causes a high rate of self-pollination. The first seeds mature about 6 weeks after sowing. In backyards with repeated pickings, *Amaranthus dubius* plants may become perennial, up to 2 years old.

Ecology *Amaranthus dubius* is frequently found in tropical humid lowland from sea level up to 500 m altitude, and also but much less at higher elevations up to 2000 m. It is a common plant in waste places, roadsides, flood plains, river banks and cleared forest areas. It shows a weak quantitative short-day reaction. Vegetable amaranths grow well at day temperatures above 25°C and night temperatures not lower than 15°C. Shade is disadvantageous except in cases of drought stress. Amaranths like fertile, well-drained soils with a loose structure.

Propagation and planting The seed of *Amaranthus dubius* is smaller than that of other cultivated amaranths, with 4000–6000 seeds/g. At harvest growers spare a few vigorous plants for seed. Market seed production in the field yields around 500 kg seed per ha in a five-month period. For commercial seed production an isolation distance of 200 m should be respected. In the wild and in home gardens the seed of fruiting plants scatters and gives rise to new plants automatically. The seed may remain dormant in the soil for several years. It germinates when it comes to the surface or in the top 3 cm of the soil. Yet in germination trials with vegetable types, germination was stimulated by darkness. The seed may be mixed with sand for easier sowing. It is common practice to sow directly, broadcast or in rows with about 20 cm between the rows, with a seed rate of 1–5 g/m². Another cultivation method is sowing in a nursery at a rate of 2–10 g/m² and transplanting after 2–3 weeks. From a nursery, the grower obtains up to 1000 plantlets per m² for transplanting. A plant density of 100–200 plants/m² can be practised for once-over harvesting while 25 plants/m² is appropriate for repeated cuttings. *Amaranthus dubius* is especially well-suited to repeated cutting. For market production *Amaranthus dubius* is normally grown as a sole crop on beds. It is also found in intercropping systems with food crops.

Management In fields and home gardens, the only care given to weedy *Amaranthus*

dubius plants is selective weeding. *Amaranthus dubius* is fast growing, albeit less than the more commonly cultivated *Amaranthus cruentus*. Because of the rather strong growth of *Amaranthus dubius*, weeds in transplanted plots are not very troublesome, except nut grass (*Cyperus rotundus* L.). If rainfall is not sufficient, irrigation by sprinkling should be done before the plants reach their wilting point. *Amaranthus dubius* is much more susceptible to drought than *Amaranthus cruentus*. Watering every day with 6 mm (6 l/m²) is sufficient. Water shortage causes early flowering, which reduces the yield and the market quality. Amaranth is a very high consumer of minerals. On poor soils only modest crops can be produced. Amaranth responds to high rates of organic fertilizer. In some places it is grown on large quantities (up to 50 t/ha) of almost fresh town refuse, which fulfils its need for nutrients. On poor soils, the application of 400 kg/ha of NPK 10–10–20 in addition to 25 t of organic manure is recommended. A split application is recommended during the rainy season. Nitrate-N is better than ammonium-N. Amaranth does not seem to need to be rotated with other crops since no serious soilborne disease has been observed.

Diseases and pests In general *Amaranthus dubius* is susceptible to the main pests and diseases of *Amaranthus cruentus*, but it is less susceptible to stemrot caused by the fungus *Choanephora cucurbitarum*, the main disease of *Amaranthus cruentus*, and to damping-off caused by *Pythium*. For this reason the former is recommended for cultivation during the rainy season. No virus diseases have been reported. Amaranth is not very susceptible to nematode damage.

Insects are a serious problem for amaranth growers. Caterpillars (*Hymenia recurvalis*, *Spodoptera litura*, *Heliothis armigera*) and sometimes grasshoppers are the most harmful pests. The larvae of the stem borer *Lixus truncatulus* may cause much damage, sometimes already in the seedbed. The basal part of the plant containing the pupae swells and the plant growth is much retarded. Many other insects such as aphids, leaf miners, stinkbugs, mole crickets, as well as mites attack amaranth but generally cause only minor damage. Commercial growers now spray insecticides instead of using the traditional control method of spreading wood ash to dispel insects.

Weedy *Amaranthus dubius* is a host plant for the bacterium *Xanthomonas campestris* affecting tomato and for the nematode *Rotylenchulus reniformis* affecting banana.

Harvesting Commercial growers harvest by uprooting, by cutting at ground level or by ratooning. If the crop is sown directly, a once-over harvest by uprooting or by cutting at ground level may be done 3–4 weeks after sowing. Some growers obtain a second harvest 3 weeks later from the regrowth of the smallest plants. When ratooning is practised, the first cutting takes place about one month after transplanting, and then every 2–3 weeks for a period of 1–2 months. Cutting should be done at such a height that at least 2 leaves and buds are left behind for regrowth; the best cutting height is 10–15 cm.

Yield Commercial growers harvest 1.5–2.5 kg/m² of an uprooted crop (dry matter content 16%, edible portion 35–50%); the first cutting of a ratooned crop may yield 1–2 kg/m² (edible portion 70–80%), subsequent cuttings about 1 kg/m²

Handling after harvest The harvested plants or shoots are bundled, the roots are washed, and the produce is packed for transport to the market. In markets and shops, it is sprinkled with water to keep a fresh appearance. If uprooted, the vegetable can be kept fresh for some days by putting it in a basin with the roots in the water. It is sold in bunches or by weight.

Genetic resources *Amaranthus dubius* is present in Indian collections at the National Bureau of Plant Genetic Resources (NBPGR), New Delhi (India). Some East and southern African research institutes may have small working collections of local cultivars. Evaluation and variability studies are needed to reveal the amount of exploitable genetic variation.

Breeding Breeding of *Amaranthus dubius* as a leafy vegetable has been carried out at Tamil Nadu Agricultural University, Coimbatore, India; several commercial cultivars are available.

Prospects *Amaranthus dubius* is recognized as an easy-to-grow, productive and nutritious vegetable, especially for the rainy season. Research should focus on optimization of cultural practices (integrated pest management to avoid pesticide residues, plant nutrition).

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Sauer, J.D., 1967; Schippers, R.R., 2000; Stevels, J.M.C., 1990; Townsend, C.C., 1985.

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Sources of illustration Stevels, J.M.C., 1990.

Authors G.J.H. Grubben

AMARANTHUS GRAECIZANS L.

Protologue Sp. pl. 2: 990 (1753).

Family Amaranthaceae

Chromosome number $2n = 32, 34$

Synonyms *Amaranthus angustifolius* Lam. (1783), *Amaranthus silvestris* Vill. (1807), *Amaranthus thellungianus* Nevski (1937).

Vernacular names Wild amaranth, prostrate amaranth, spreading pigweed (En). Amarante sauvage, amarante sylvestre, amarante africaine (Fr). Tristes, amaranto, bredo (Po). Mchicha (Sw).

Origin and geographic distribution *Amaranthus graecizans* occurs scattered throughout tropical Africa, where it has been recorded for many countries. It is also distributed in southern Europe and in tropical and subtropical Asia, and has been introduced to the United States. It is especially popular as a vegetable in parts of Kenya, Uganda, Tanzania, Malawi and elsewhere in southern Africa, and is sometimes a protected weed in backyards and home gardens. It is locally cultivated on a small scale in home gardens e.g. by the Acholi people in Nebbi, Uganda, and in Tanzania for market sale to people of Indian origin.

Amaranthus graecizans – wild and planted

Uses The main use of *Amaranthus graecizans* is as a cooked leaf vegetable. In many countries it is collected as a potherb from the wild. Especially older people appreciate the slightly bitter taste. A major drawback is that the leaves are small and collection takes time. Because of the many flowers, people will not cook the whole shoot but they pick the individual leaves, which is one reason why this amaranth has a low market value. In some regions it is eaten mixed with other leaf vegetables collected from the wild, e.g. by the Okiek people in Western Kenya, who mix it commonly with *Solanum* or *Rumex* species and *Urtica massaica* Mildbr.

Amaranthus graecizans is used as a fodder for livestock. In Mauritania the seed is baked into thin cakes, while in the western United States it is ground into flour. Like other wild amaranths, whole plants of *Amaranthus graecizans* are used in East and West Africa to manufacture a local salt. For this purpose, the plants are dried and burned to ashes, the filtrate is evaporated and the residue used as a substitute for common salt. In Uganda, the leaves are chewed and the liquid swallowed to treat tonsillitis. In Senegal, the leaves are used as an anthelmintic.

Production and international trade *Amaranthus graecizans* is occasionally sold at markets as a low-value vegetable, but there are no records on production and trade.

Properties The composition of *Amaranthus graecizans* leaves is comparable to that of other amaranths. The average composition of amaranth leaves per 100 g edible portion is: water 84.0 g, energy 176 kJ (42 kcal), protein 4.6 g, fat 0.2 g, carbohydrate 8.3 g, fibre 1.8 g, Ca 410 mg, P 103 mg, Fe 8.9 mg, β-carotene 5716 μg, thiamin 0.05 mg, riboflavin 0.42 mg, niacin 1.2 mg, ascorbic acid 64 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). The dry matter content is high (9–22%), as well as the micronutrient content, especially calcium, iron, carotene, folate and vitamin C, if compared to other leaf vegetables. The calcium is partly insoluble and not taken up in the digestive tract, as it is bound to oxalate. The bioavailability of iron is 6–12%. The leaves become soft after 5–10 minutes cooking in slightly salted water. The nitrate (mostly in the stems) and oxalate levels are high, but cooking in ample water removes most of these toxic components. The presence

of hydrocyanic acid and oxalic acid makes it less suitable for fresh consumption by humans and as fodder for animals.

Adulterations and substitutes In dishes with green leafy vegetables or potherbs, *Amaranthus graecizans* may be replaced by any other vegetable amaranth.

Description Small annual herb up to 45(–70) cm tall, prostrate or decumbent, often strongly branched from the base and usually also above; stem and branches slender to stout, angular, glabrous or thinly furnished with short to long, crisped, multicellular hairs. Leaves arranged spirally, simple, without stipules; petiole 3–5 cm long, sometimes longer than lamina; lamina broadly ovate or rhombic-ovate to narrowly linear-lanceolate, 0.5–5.5 cm × 0.2–3 cm, cuneate to long-attenuate at base, acute to blunt or obscurely retuse at apex, entire, glabrous or with a few short glandular hairs on the lower surface of the venation. Inflorescence an axillary cluster, with male and female flowers intermixed but male flowers most frequent in upper clusters; bracts up to 2 mm long, with short or long awn. Flowers unisexual, subsessile, with 3 tepals up to 2 mm long, having a short awn; male flowers with 3 stamens; female flowers with superior, 1-celled ovary crowned by 3 stigmas. Fruit a globose to shortly ovoid capsule up to 2.5 mm long, with a very short beak below the stigmas, usually strongly wrinkled, usually circumscissile, 1-seeded. Seed compressed, 1–1.5 mm long, faintly reticulate, black.

Amaranthus graecizans – 1, plant habit; 2, fruit; 3, seed.
Redrawn and adapted by Iskak Syamsudin

Other botanical information *Amaranthus* comprises about 70 species, of which about 40 are native to the Americas. It counts at least 17 species with edible leaves. *Amaranthus graecizans* resembles *Amaranthus thunbergii* Moq., but may be distinguished by its branched habit, glabrous stems or furnished with few hairs, and by the short awn of the tepals. *Amaranthus sparganiocephalus* Thell. is another weedy amaranth locally collected as a leafy vegetable; it differs in its globular head-like inflorescences and fruits arranged in a star-shaped pattern.

Amaranthus graecizans is variable. Three subspecies are distinguished: subsp. *graecizans*, with leaves oblong to linear-lanceolate (at least 2.5 times as long as broad) and short tepal awns; subsp. *silvestris* (Vill.) Brenan, with leaves broadly ovate to rhombic-ovate or elliptical-ovate (less than 2 times as long as broad) and short tepal awns; and subsp. *thellungianus* (Nevski) Gusev, with leaves rhombic-spatulate to narrowly linear-lanceolate and long tepal awns. These subspecies are sympatric in some regions, and then intermediate forms may be common, e.g. in Ethiopia. Subsp. *graecizans* is most common in West Africa, subsp. *silvestris* in East Africa, and subsp. *thellungianus* mainly occurs in southern Africa.

Growth and development Emergence of the seedling takes place 3–5 days after sowing. The vegetative development is fast. The genus *Amaranthus* is characterized by the C_4-cycle photosynthetic pathway, which means a high photosynthesis at high temperature and radiation. Flowering may start 4–8 weeks after sowing. The growth of new shoots continues after the start of flowering. Pollination is effected by wind but the abundant pollen production, especially in the upper part of flowering plants, causes a high rate of self-pollination. Seeds mature after 1–2 months.

Ecology Amaranths in general perform best on fertile, well-drained soils with a loose structure, but *Amaranthus graecizans* also grows

well on poor soils. It is very resistant to adverse climate and soil conditions. It is found on waste or cultivated ground, forest edges and grassland, mostly in arid areas but also in marshy or flooded land, from sea level to 2400 m, in regions with an annual rainfall of 600–1800 mm. If there is less rainfall, it is only found during the rainy season. It grows well in somewhat shaded conditions.

Propagation and planting In the wild and in home gardens the seed of fruiting plants is scattered and gives rise to new plants. Dormant seed remains viable in the soil for several years. It germinates at the surface or in the upper 3 cm of the soil. Seeds can be obtained by rubbing mature infructescences. The seeds can be sown directly, broadcast or in rows with 15–20 cm between the rows, with a seed rate of 2–5 g/m^2. Another cultivation method is sowing in a seedbed (nursery) at a seed rate of 3–10 g/m^2 and transplanting after 2–3 weeks. A plant density of 100–200 plants/m^2 can be practised for a once-over harvest, whereas 25 plants/m^2 is appropriate for repeated cuttings.

Management Cultivation is relatively easy; the same technology as for *Amaranthus blitum* L. may be applied. Where *Amaranthus graecizans* is appreciated as a vegetable, selective weeding may be applied by removal of all other weeds. Water shortage causes early flowering, which reduces yield and market quality. Amaranth is a very high consumer of minerals. On poor soils only modest crops are produced.

Diseases and pests Although information is limited, *Amaranthus graecizans* seems to be very tough and resistant to pests and diseases. It is a host plant of *Verticillium* fungi, which may cause damage to tomato.

Harvesting Young plants and young tender shoots are picked as a vegetable. When whole plants are harvested they are uprooted after 4–5 weeks. When plants are harvested several times, it is advised to pick individual leaves when seeds have started maturing because stray seeds in prepared food feel like sand in the mouth.

Handling after harvest If collected for the market, shoots and leaves are often sprinkled with water to keep a fresh appearance.

Genetic resources *Amaranthus graecizans* is widespread and usually occurs in disturbed habitats, and thus does not seem to be threatened by genetic erosion. The genetic variation in this polymorphic species seems considerable.

Prospects *Amaranthus graecizans* is a tasty and nutritious traditional wild vegetable, in which there is decreasing interest. The prospects for domestication and cultivation as vegetable are poor because it would have to compete with higher yielding amaranths, such as the commonly cultivated *Amaranthus cruentus* L., *Amaranthus blitum* L., *Amaranthus dubius* Mart. ex Thell. and *Amaranthus tricolor* L. In breeding of cultivated amaranths, *Amaranthus graecizans* might be used as genitor of resistance genes.

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Sources of illustration Hegi, G., 1979b; Townsend, C.C., 1985.

Authors P.M. Maundu & G.J.H. Grubben

AMARANTHUS HYPOCHONDRIACUS L.

Protologue Sp. pl. 2: 991 (1753).

Family Amaranthaceae

Chromosome number $2n = 32, 34$

Synonyms *Amaranthus hybridus* auct. non L.

Vernacular names Prince's feather, amaranth (En). Amarante, brède malabar (Fr). Amaranto, bredo (Po). Mchicha (Sw).

Origin and geographic distribution *Amaranthus hypochondriacus* originates from North America, possibly as a hybrid between the north American wild *Amaranthus powellii* S.Wats. and the cultivated *Amaranthus cruentus* L. *Amaranthus hypochondriacus* is now widely cultivated worldwide, in tropical, subtropical and temperate climates, but mainly as a grain and ornamental crop. It is also found in tropical Africa (e.g. Kenya), but its exact distribution is unknown because of confusion with related species.

Uses *Amaranthus hypochondriacus* leaves are occasionally used as a potherb and the seeds are used as a grain. Its use as a grain crop is most important in Central and South America and in Asia. The seeds are used like maize: popped, roasted or milled. In Mexico the product is known as 'zoale' paste and 'alegría'

cake and confections. In the Himalayas bread made from the seeds is very popular and the popularity of *Amaranthus hypochondriacus* as a grain crop in India is increasing. In Africa it is experimentally tried as a leafy vegetable. *Amaranthus hypochondriacus* is also grown as an ornamental.

Properties Amaranth leaves contain per 100 g edible portion: water 84.0 g, energy 176 kJ (42 kcal), protein 4.6 g, fat 0.2 g, carbohydrate 8.3 g, fibre 1.8 g, Ca 410 mg, P 103 mg, Fe 8.9 mg, β-carotene 5716 μg, thiamin 0.05 mg, riboflavin 0.42 mg, niacin 1.2 mg, ascorbic acid 64 mg. The composition of the seeds of grain amaranth per 100 g edible portion is: water 12.7 g, energy 1495 kJ (356 kcal), protein 14.0 g, fat 6.0 g, carbohydrate 63.1 g, fibre 9.4 g, Ca 490 mg, P 455 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968).

In Western countries amaranth seed is recommended as a health food. The protein is characterized by the high lysine content (3.2–18%). The oil has antioxidant properties. The starch consists mainly of amylopectin; the very small starch granules make grain amaranth an attractive raw material for industrial uses. The significant amount of squalene (4–11% of the oil portion) means that grain amaranth may find a market niche for industrial production of products such as lubricants in the computer industry and in cosmetics and health foods.

Botany Annual herb, erect or less commonly ascending, up to 2 m tall, often reddish tinted throughout; stem stout, branched, angular, glabrous or sparsely to moderately densely furnished with multicellular hairs. Leaves arranged spirally, simple, without stipules, long-petiolate; blade broadly lanceolate to rhombic-ovate, 2–18 cm × 2–15 cm, attenuate or shortly cuneate at base, obtuse to subacute at apex, mucronate, entire, glabrous to sparsely pilose, pinnately veined. Inflorescence stiff with thick branches, large and complex, consisting of numerous agglomerated cymes arranged in axillary and terminal spikes, the terminal one up to 45 cm long, usually with many lateral, perpendicular, thin branches. Flowers unisexual, subsessile; bracteoles 3–5 mm long and always longer than the tepals; tepals 5, lanceolate, 1–2 mm long with one equal to or longer than the fruit, the other 4 shorter; male flowers with 5 stamens c. 1 mm long; female flowers with superior, 1-celled ovary crowned by 3 thick, spreading stigma branches about 1.7 mm long. Fruit an obovoid to rhombic capsule 1.5–2 mm long, circumscissile, with a short beak, 1-seeded. Seed obovoid to ellipsoid, compressed, c. 1 mm long, whitish to yellowish or blackish. Seedling with epigeal germination; hypocotyl 10–12 mm long; cotyledons about 18 mm × 5 mm, fleshy, petiolate.

Amaranthus comprises about 70 species, of which about 40 are native to the Americas. It includes at least 17 species with edible leaves and 3 grain amaranths. *Amaranthus hypochondriacus* belongs to both categories. *Amaranthus hypochondriacus* is part of the so-called *Amaranthus hybridus* complex, a group of species in which taxonomic problems are far from clarified because of apparently common hybridization and nomenclatural disorder caused by misapplication of names. Several cultivars of *Amaranthus hypochondriacus* exist; most of these have pale seeds, but some have black seeds.

Ecology *Amaranthus hypochondriacus* as a vegetable amaranth grows well at day temperatures above 25°C and night temperatures not lower than 15°C, but it is grown as a grain crop up to 2000 m altitude in the Himalayas. Shade is disadvantageous except in cases of drought. Amaranth is a quantitative short-day plant, which is an advantage in the subtropics, where the conversion to the generative stage is retarded during summer. Amaranths like fertile, well-drained soils with a loose structure. The mineral uptake is very high. Although *Amaranthus hypochondriacus* is fairly tolerant of adverse climate and soil conditions, escapes growing as a weed tend to disappear because they cannot compete with true weeds like *Amaranthus spinosus* L. or *Amaranthus hybridus* L.

Management Commercially vegetable amaranth is usually grown as a sole crop on beds. It is also found in intercropping systems with food crops and in home gardens. There are 2500–3500 seeds/g. The common cultivation practice is sowing in a nursery at a seed rate of 3–10 g/m^2 and transplanting after 2–3 weeks. Wet rot or stemrot caused by the fungus *Choanephora cucurbitarum* is the main disease. It is favoured by wet conditions, low soil fertility and high nitrogen doses. Insects are a serious problem for amaranth growers. Caterpillars (*Spodoptera litura*, *Helicoverpa armigera*, *Hymenia recurvalis*) and sometimes grasshoppers are the most harmful. Most commercial amaranth growers harvest whole plants by uprooting 20–30 days after transplanting. Good growers normally harvest 20–25 t/ha (maximum 30 t/ha) of an uprooted crop (dry matter

content 16%, edible portion 35–50%, being the total of leaves and young stems). The harvested plants are bundled, the roots are washed and the produce is packed for transport to the market. In markets and shops it is sprinkled with water to keep a fresh appearance. If uprooted, the vegetable can be kept fresh for some days by putting it in a basin with the roots in the water. It is sold in bunches or by weight.

Genetic resources and breeding A collection of amaranths is kept at the Rodale Organic Gardening and Farming Research Center (OGFRC) at Kutztown, Pennsylvania, United States; South-East Asian accessions are kept at the Asian Vegetable Research and Development Center (AVRDC) at Tainan, Taiwan. African cultivars and introductions from OGFRC are kept at the National Horticultural Research Institute (NIHR) in Nigeria and African cultivars at the AVRDC centre at Arusha, Tanzania. Indian collections are maintained at the National Bureau of Plant Genetic Resources (NBPGR) in New Delhi, India. Many national institutes have small working collections of local cultivars. Evaluation and variability studies are needed to reveal the amount of exploitable genetic variation. Breeding of *Amaranthus hypochondriacus* as a leafy vegetable does not occur; all efforts are directed toward development of good seed cultivars.

Prospects *Amaranthus hypochondriacus* is only occasionally used as a vegetable – its major importance, at least in America and Asia, will remain its use as a seed crop. To finally settle the name confusion, more research is needed to unravel completely the taxonomic and relational problems of the *Amaranthus hybridus* complex. This will also elucidate the distribution and importance of *Amaranthus hypochondriacus* in Africa, which are unclear at the moment.

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Other references Townsend, C.C., 1985.

Authors P.C.M. Jansen

AMARANTHUS SPINOSUS L.

Protologue Sp. pl. 2: 991 (1753).

Family Amaranthaceae

Chromosome number $2n = 34$

Vernacular names Spiny amaranth, prickly amaranth, spiny pigweed (En). Amarante épineuse, épinard malabar, épinard piquant (Fr). Amaranto, bredo (Po). Mchicha (Sw).

Origin and geographic distribution *Amaranthus spinosus* originates probably from lowland tropical South and Central America and was introduced into other warmer parts of the world from about 1700 AD onwards. At present it occurs in all tropical and subtropical regions, including tropical Africa, often gregariously and as a weed. It is sometimes found in temperate zones as well. It is rarely cultivated.

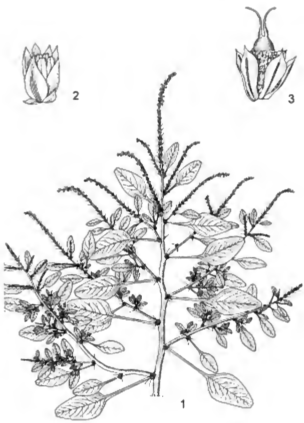
Uses In tropical Africa and elsewhere *Amaranthus spinosus* leaves and young plants are collected for home consumption as a cooked, steamed or fried vegetable, especially during periods of drought. Leaves are occasionally found for sale on markets. In Uganda and Kenya it commands a lower price than, for example, *Amaranthus dubius* Mart. ex Thell. because of its spines and because it is not much liked. Its use is declining, and it is acquiring the status of a famine food. It has a bitter taste and is usually eaten in small quantities as a substitute when no other vegetables are available. *Amaranthus spinosus* is also used as forage and said to increase the yield of milk in cattle. However, the spines can cause injury to the mouths of grazing animals and cases of poisoning in cattle have also been reported.

In Uganda the ash of burnt *Amaranthus spinosus* plants is used as a tenderizer in cooking tough vegetables such as cowpea leaves and pigeon peas. The ash is also used as a vegetable salt and in southern Africa it is used as a snuff, alone or with tobacco.

Amaranthus spinosus has numerous medicinal uses. The root is known as an effective diuretic. In South-East Asia a decoction of the root is used to treat gonorrhoea and is also applied as an emmenagogue and antipyretic. In many countries, including those in Africa, the bruised leaves are considered a good emollient and applied externally in cases of eczema, burns, wounds, boils, earache and haemorroids. The plant ash in solution is used to wash sores. Plant sap is used as an eye wash to treat ophthalmia and convulsions in children. In Malaysia *Amaranthus spinosus* is used as an expectorant and to relieve breathing in acute bronchitis. In mainland South-East Asia, it is also used as a sudorific, febrifuge, antidote to snake poison, galactagogue, and to treat menorrhagia. Some tribes in India apply *Amaranthus spinosus* to induce abortion.

Properties The nutritional value of *Amaranthus spinosus* is comparable to that of other vegetable amaranths. *Amaranthus* leaves contain per 100 g edible portion: water 84.0 g, energy 176 kJ (42 kcal), protein 4.6 g, fat 0.2 g, carbohydrate 8.3 g, fibre 1.8 g, Ca 410 mg, P 103 mg and Fe 8.9 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). Cases of spontaneous poisoning in cattle by *Amaranthus spinosus* have been reported, particularly after severe droughts when few other forages were available. It was suggested that *Amaranthus spinosus* caused renal failure. The roots contain α-spinasterol and some saponins. Sterols, n-alkanes, fatty acids and free alcohols have been found in petroleum-ether extracts of the herb. The flavonoid rutin has been found in the aboveground parts in a concentration of up to 1.9%, and traces of hydrocyanic acid in the leaves. The considerable amount of potassium in the leaves might explain the diuretic properties. A lectin has been isolated from the seeds. Its reaction was non-specific in general: it reacted with human and various animal erythrocytes. Its unique carbohydrate specificity will prove useful in biochemistry.
Amaranthus spinosus possesses a strong phagocytic effect. No antibacterial activity has been demonstrated, but crude aqueous extracts showed fungicidal activity against *Cercospora cruenta*, which causes a leafspot disease in mung bean (*Vigna radiata* (L.) Wilczek). They showed antiviral activity against Aujeszky virus (ADV) in IB-RS-2 pig cell cultures and bovine diarrhoea virus (BVDV) in GBK bovine cell lines. The antiviral activity against BVDV, however, was lost upon heating the extract.
Allelochemicals have been isolated and identified from aerial plant parts. These are volatile aliphatic compounds which inhibit germination of seeds of crops like carrot, tomato and onion.

Botany Annual, erect, monoecious herb, up to 100(–130) cm tall, much branched; stem terete or obtusely angular, glabrous or slightly pubescent, green or variably suffused with purple. Leaves alternate, simple; stipules absent; petiole approximately as long as leaf-blade; blade ovate-lanceolate to rhomboid, 3.5–11 cm × 1–4.5 cm, acute and often slightly decurrent at base, obtuse, rounded or slightly retuse and often short mucronate at apex, entire, glabrous or slightly pubescent on veins when young. Inflorescence consisting of dense clusters, lower ones axillary, higher ones often collected in an axillary and terminal spike which is often branched in its lower part; axil



Amaranthus spinosus – 1, part of flowering plant; 2, male flower with bracteoles; 3, fruit. Source: PROSEA

lary clusters usually armed with (1–)2(–3) very sharp spines up to 2 cm long. Flowers unisexual, solitary in the axil of a bract, subtended by 2 bracteoles; bracts and bracteoles scarious, mucronate from a broad base, shorter or as long as the perianth; male flowers usually arranged in a terminal spike above the base of the inflorescence, green; tepals 5 or in male flowers often 3, free, subequal, ovate-oblong to oblong-spatulate, up to 2.5 mm long, very convex, membranous, with transparent margins and green or purple median band; male flowers with 5 stamens about as long as tepals; female flowers with superior, oblong ovary, 1-celled, styles 2–3, ultimately recurved. Fruit an oblong capsule with persisting styles, circumscissile a little below the middle or indehiscent, 1-seeded. Seed about 1 mm in diameter, shiny black or brownish-black with thin margin. Seedling with epigeal germination; cotyledons leafy, glabrous, apex rounded to slightly acute; hypocotyl up to 12 mm long, epicotyl absent.
Amaranthus comprises about 70 species, of which about 40 are native to the Americas. It includes at least 17 species with edible leaves.

It is almost impossible to make a distinction between *Amaranthus spinosus* and *Amaranthus dubius* Mart. ex Thell. based on morphological characters; *Amaranthus spinosus* has axillary spines which are not present in *Amaranthus dubius*. However, spineless *Amaranthus spinosus* plants with $2n = 34$ have been observed in several localities. In Nigeria an *Amaranthus dubius* plant with $2n = 32$ has been recorded; this might be a spineless *Amaranthus spinosus*. Other more or less reliable differences are the greater number of terminal male flowers in the inflorescences of *Amaranthus spinosus* and the smaller pores of the pollen.

Seeds mature about one month after flowering. They are scattered around the mother plants or distributed by animals feeding on the plants. It has been observed that large numbers of seedlings emerge from decaying cattle faecal deposits. Seeds are eaten by birds.

Ecology *Amaranthus spinosus* is adapted to a wide range of climatic and edaphic factors. It grows best in the sun or in light shade; a light intensity of less than 30% completely suppresses flowering. Flowering is earliest and most abundant in areas with daylengths of 11–12 hours. Spiny amaranth is nitrophilous and prefers soils with a high organic matter content, but is also able to grow on sandy soils. Optimal growth is obtained on soils with moderate moisture content, but *Amaranthus spinosus* is capable of growing on wet soils as well. It is drought-resistant and can even grow under arid conditions.

Spiny amaranth is a very noxious weed in many parts of the world. It is, for instance, troublesome in maize, cassava and groundnut in Ghana, in cotton in Mozambique, and in sugar cane in South Africa. In general, it is very common in roadsides, waste places, railway yards, cropped land and gardens, up to 1400 m altitude.

Management *Amaranthus spinosus* is propagated by seed. Some types are known to produce 235,000 seeds per plant. The weight of 1000 seeds is 140–250 mg. Freshly collected seeds may germinate at temperatures as high as 40°C, with a germination rate of up to 95%. After storage, however, temperature requirements are lower. Seeds stored for one month at room temperature have almost 100% germination, and after 5 months they have approximately 90% germination. When they are stored for one year at 20°C the germination rate will drop to about 50%. but storage at lower temperatures gives a higher rate. Seedlings often exhibit a high degree of mortality. For use as a vegetable, the plants are mostly collected while still young before the spines have hardened.

As a weed in tomato in India, spiny amaranth has been successfully controlled by the application of geraniol, which completely blocked the germination of the weed without affecting the tomato crop. An ethanolic extract of seeds of *Coffea arabica* L. (with 1,3,7-trimethylxanthine as active ingredient) at a concentration of 1.2 g/l, completely inhibited germination of spiny amaranth in a crop of black gram (*Vigna mungo* (L.) Hepper) without negative effects to this pulse crop.

Amaranthus spinosus is a host plant for, among others, tobacco mosaic virus, groundnut rosette virus, cucumber mosaic virus and root-knot nematodes (*Meloidogyne* spp.), which attack some commercial crops. When the world's worst weeds are ranked on the basis of the number of pests hosted, *Amaranthus spinosus* is placed number 6, hosting 15 pests that may affect crops. Some insects attacking *Amaranthus spinosus* have been recorded from Mexico: the pyralid *Herpetogramma bipunctalis* and the curculionid *Conotrachelus seniculus*. These might be useful for biological control.

Genetic resources and breeding The genetic variability of *Amaranthus spinosus* is great because of its large area of distribution and its wide ecological adaptation. A collection of amaranths is kept at the Rodale Organic Gardening and Farming Research Center (OGFRC) at Kutztown, Pennsylvania, United States; South-East Asian accessions are kept at the Asian Vegetable Research and Development Center (AVRDC) at Tainan, Taiwan. African cultivars and introductions from OGFRC are kept at the National Horticultural Research Institute (NHR) in Nigeria and African cultivars at the AVRDC centre at Arusha, Tanzania. Indian collections are kept at the National Bureau of Plant Genetic Resources (NBPGR), New Delhi, India. Many national institutes have small working collections of local cultivars. Evaluation and variability studies are needed to reveal the amount of exploitable genetic variation.

Prospects Despite the reputed high nutritional value of the leaves, *Amaranthus spinosus* most probably will remain a famine vegetable and forage because of the rather poor taste and the spines. The medicinal properties of *Amaranthus spinosus* have received little attention. The diuretic and anti-inflammatory

properties in particular deserve more research, as these properties are valued in many different regions of the world.

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Other references Burkill, H.M., 2000; CSIR, 1985; Gopal, B., 1974; Koseki, I. et al., 1990; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Oliveira, J.S. & de Carvalho, M.F., 1975; Schippers, R.R., 2000; Stevels, J.M.C., 1990; Townsend, C.C., 1985; Townsend, C.C., 1988.

Sources of illustration Lemmens, R.H.M.J. & Bunyapraphatsara, N., 1999.

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Based on PROSEA 12(1): Medicinal plants 1.

AMARANTHUS THUNBERGII Moq.

Protologue DC., Prodr. 13(2): 262 (1849).

Family Amaranthaceae

Vernacular names Wild amaranth, wild spinach, pigweed (En). Amarante sauvage (Fr).Amaranto, bredo (Po). Mchicha (Sw).

Origin and geographic distribution *Amaranthus thunbergii* is native to Central, East and southern Africa, where it has been recorded as a weed in many countries, from Congo east to Eritrea and Somalia, and south to South Africa. It has been introduced as weed into Australia and Europe, probably with sheep.

Uses The main use of *Amaranthus thunbergii* is as a collected potherb. In Botswana it is a popular leaf vegetable eaten fresh or dried; it is eaten with milk or fat in combinations with sorghum or maize. In Namibia it is eaten with a porridge of pearl millet. The leaves are rather bitter when compared to other amaranth species. It is a popular vegetable also among the Asian population living in South Africa. It is used as a fodder for livestock. In Zimbabwe the ground and dried flower heads are used to make tobacco snuff milder.

Amaranthus thunbergii – wild

Production and international trade *Amaranthus thunbergii* is not commercially cultivated. It is occasionally sold at markets in Botswana and Namibia as a cheap vegetable.

Properties The composition of *Amaranthus thunbergii* leaves is comparable to that of other amaranths. Leaves of amaranths contain on average per 100 g edible portion: water 84.0 g, energy 176 kJ (42 kcal), protein 4.6 g, fat 0.2 g, carbohydrate 8.3 g, fibre 1.8 g, Ca 410 mg, P 103 mg, Fe 8.9 mg, β-carotene 5716 µg, thiamin 0.05 mg, riboflavin 0.42 mg, niacin 1.2 mg, ascorbic acid 64 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). The leaves and stems contain nitrate, most in the stems, and also oxalate at a level comparable to other green leaf vegetables. Most people cook amaranth in ample water and the cooking water with soluble nitrate and oxalate is thrown away. To reduce bitterness the leaves may also be cooked twice. The presence of a rather high content of hydrocyanic acid and oxalic acid makes it less suitable for fresh consumption by humans and as fodder for animals. However, in a test with sheep no toxic effects of large rations of *Amaranthus thunbergii* were found.

Adulterations and substitutes In dishes with green leafy vegetables or potherbs, *Amaranthus thunbergii* may be replaced by any other vegetable amaranth.

Description Small annual herb up to 55 cm tall, erect or ascending, simple or branched from the base and frequently also above; stem and branches stout, angular, glabrous or thinly hairy below, upwards increasingly furnished with long, crisped, multicellular, rather flocculent hairs. Leaves arranged spirally, simple, without stipules; petiole up to 4 cm long, sometimes longer than lamina; lamina narrowly elliptical to rhomboid or spatulate, (0.5–)1.5–4.5(–6) cm × (0.5–)1–3(–4) cm, cuneate to attenuate at base, blunt or retuse at apex, entire, glabrous or thinly pilose on the lower surface of the primary venation, sometimes with a dark purple blotch. Inflorescence an axillary cluster up to 1.5 cm in diameter, with male and female

flowers intermixed but male flowers most frequent at the top of upper clusters; bracts up to 6 mm long, with long awn. Flowers unisexual, subsessile, with 3 tepals up to 6 mm long, having a long, fine awn; male flowers with 3 stamens; female flowers with superior, 1-celled ovary crowned by 3 stigmas. Fruit an ovoid-ellipsoid to pyriform capsule up to 3.5 mm long, with a short beak below the stigmas, circumscissile, obscurely wrinkled, 1-seeded. Seed 1–1.5 mm long, shining black or dark brown, feebly reticulate.

Other botanical information *Amaranthus* comprises about 70 species, of which about 40 are native to the Americas. It counts at least 17 species with edible leaves. *Amaranthus thunbergii* resembles *Amaranthus graecizans* L., but may be distinguished by its stems furnished with long crisped hairs, leaves broadest above the middle and having a rounded top, and by the long awn of the tepals.

Growth and development Emergence of the seedling takes place 3–5 days after sowing. The vegetative development is fast. Like maize and sugar cane, the genus *Amaranthus* is characterized by the C_4-cycle photosynthetic pathway, which means a high photosynthesis at high temperature and radiation. Flowering may start 4–8 weeks after sowing and occurs from February to May in southern Africa. The growth of new shoots continues after the start of flowering. Pollination is effected by wind but the abundant pollen production causes a high rate of self-pollination. Seeds mature after 1–2 months.

Ecology *Amaranthus thunbergii* occurs on waste places, as a weed on cultivated ground, grassland and rocky soil, mostly in arid highland areas. In Botswana it grows on various soil types under a wide range of environmental conditions, but is most frequently found in seasonally wet localities, e.g. along watercourses. *Amaranthus thunbergii* is very resistant to adverse climate and soil conditions.

Propagation and planting The seed is scattered and gives rise to spontaneous new plants. It is also spread with cow dung, and may remain viable in the soil for many years. It germinates at the surface or in the upper soil layer of less than 3 cm.

Management Where *Amaranthus thunbergii* is appreciated as a vegetable, selective weeding may be applied by removal of all other weed plants. Cultivation of *Amaranthus thunbergii* is only occasionally recorded, e.g. in Botswana, where its cultivation during the dry season is being tested. Presumably cultivation is relatively easy; the same technology as for *Amaranthus blitum* L. may be applied. Once that the plant is established, it is self-seeding.

Diseases and pests Although data are lacking, *Amaranthus thunbergii* seems to be very tough and resistant to pests and diseases.

Harvesting Young plants and young tender shoots are picked as a vegetable. People start to collect the young shoots three weeks after the rains have started. Repeated harvesting stimulates the growth of new shoots.

Handling after harvest If collected for the market, shoots and leaves are often sprinkled with water to keep a fresh appearance. In Namibia, the leaves are boiled and prepared in flattened cakes that are sun-dried for use during the dry season.

Genetic resources *Amaranthus thunbergii* is widespread and usually occurs in disturbed habitats, and thus does not seem to be threatened by genetic erosion. It is not included in germplasm collections.

Prospects *Amaranthus thunbergii* is a tasty and nutritious traditional wild vegetable. The prospects for domestication and cultivation as vegetable are poor because it would have to compete with more popular vegetable amaranths. In breeding of cultivated amaranths *Amaranthus thunbergii* might be used as genitor of resistance genes.

Major references Grubben, G.J.H., 1993a; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Madisa, M.E. & Tshamekang, M.E., 1997; Matlhare, T. et al., 1999; Schippers, R.R., 2000; Townsend, C.C., 1985; Townsend, C.C., 1988; Townsend, C.C., 2000.

Other references Schneider, D.J., 1978.

Authors G.J.H. Grubben

AMARANTHUS TRICOLOR L.

Protologue Sp. pl. 2: 989 (1753).

Family Amaranthaceae

Chromosome number $2n = 34$

Synonyms *Amaranthus tristis* L. (1753), *Amaranthus gangeticus* L. (1759).

Vernacular names Amaranth, Joseph's coat (En). Amarante, brède de Malabar (Fr). Amaranto, bredo (Po). Mchicha (Sw).

Origin and geographic distribution *Amaranthus tricolor* originates from tropical Asia. In South and South-East Asia it is one of the major leaf vegetables and the most important *Amaranthus* species. Its domestication took

Amaranthus tricolor – *planted*

place in prehistoric times and the wild ancestor is not known. Weedy plants of *Amaranthus tricolor* can be found occasionally. They are recently escaped from cultivation, since *Amaranthus tricolor* is far from competitive with true weeds. *Amaranthus tricolor* occurs as a quite rare exotic vegetable in several African countries, apparently introduced by Indian immigrants and occasionally cultivated around the big cities, especially in East and southern Africa. Its cultivation has been reported from Benin, Nigeria, Kenya and Tanzania.

Uses *Amaranthus tricolor* is used as a cooked leaf vegetable. In Asian countries it is occasionally eaten raw in salads; the soft stems are eaten like asparagus in India. Forms with bright red and red, yellow and green-coloured leaves are grown throughout the world as ornamentals. Medicinally *Amaranthus tricolor* is used externally to treat inflammations, and internally as a diuretic.

Production and international trade In spite of its importance in Asia no production statistics on *Amaranthus tricolor* are available, as in most cases all leaf vegetables are treated as one commodity and probably also because it is mainly grown on small plots. In Africa *Amaranthus tricolor* is grown on a limited scale in home gardens or as a commercial vegetable, but it is of little economic significance.

Properties The composition of *Amaranthus tricolor* leaves is comparable to that of other amaranths such as *Amaranthus cruentus* L. Although the general dry matter content is high (9–22%), the tenderness of *Amaranthus tricolor* is reflected in its composition by a lower dry matter and lower fibre content than in other *Amaranthus* species. The moisture content and composition show large variations as a function of plant age, ecological conditions and cultural practices such as fertilizing. Amaranth leaves contain per 100 g edible proportion (89%): water 88.9 g, energy 75 kJ (18 kcal), protein 3.5 g, fat 0.3 g, carbohydrate 0.3 g, dietary fibre 2.6 g, Ca 270 mg, Mg 130 mg, P 65 mg, Fe 3.0 mg, carotene 1725 µg, thiamin 0.07 mg, riboflavin 0.22 mg, niacin 0.7 mg, folate 85 µg, ascorbic acid 42 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). The protein content of the leaves (20–38% based on dry matter) is high and includes methionine and other sulphur-containing amino acids. The content of essential micronutrients, especially calcium, iron, carotene, folate and vitamin C, is high in comparison with other vegetables. The calcium occurs partly as insoluble oxalate, which is not taken up in the digestive tract. The bioavailability of the iron is 6–12%. The leaves easily become soft after 5–10 minutes cooking in lightly salted water. Some types contain much anthocyane, a brilliant red pigment that dissolves in the cooking water, which is poured off. The leaves and stems contain the antinutrients nitrate (most in the stems) and oxalate, but adverse nutritional effects are not likely with consumption of up to 200 g per day. Moreover cooking in ample water removes toxic components. The rather high content of hydrocyanic acid and oxalic acid makes it less suitable for fresh consumption by humans and is a limiting factor for the use as fodder for animals. However, unlike other *Amaranthus* species, *Amaranthus tricolor* is sometimes consumed raw as a salad.

Adulterations and substitutes In dishes with green leafy vegetables or pot herbs, *Amaranthus tricolor* can be replaced by *Amaranthus cruentus* or other amaranths.

Description Ascending or erect annual herb up to 125 cm tall, with stout stem, usually much branched; stem and branches angular, glabrous or in the upper part with crisped hairs. Leaves arranged spirally, simple, without stipules; petiole up to 8 cm long; lamina broadly ovate, rhomboid-ovate or broadly elliptical to lanceolate-oblong, very variable in size, shortly cuneate to attenuate at base, emarginate to obtuse or acute at apex, glabrous or thinly pilose on lower surface of primary venation, green to reddish. Inflorescence an axillary, globose cluster up to 2.5 cm in diameter, the upper clusters sometimes forming a terminal spike, with male and female flowers in-

Amaranthus tricolor – 1, flowering and fruiting shoot; 2, fruit.
Redrawn and adapted by Iskak Syamsudin

termixed; bracts broadly ovate, about as long as tepals, awned. Flowers unisexual, subsessile, with 3 tepals up to 5 mm long, having a long awn; male flowers with 3 stamens; female flowers with superior, 1-celled ovary crowned by 3 stigmas. Fruit an ovoid-urceolate capsule up to 3 mm long, with a short beak below the stigmas, circumscissile, obscurely wrinkled, 1-seeded. Seed 1–1.5 mm long, shining black or brown, faintly reticulate.

Other botanical information *Amaranthus* comprises about 70 species, of which about 40 are native to the Americas. It includes at least 17 species with edible leaves.

Growth and development Emergence of the seedling takes place 3–5 days after sowing. Vegetative development is fast. Like maize and sugar cane, *Amaranthus* is characterized by the C_4-cycle photosynthetic pathway, which means a high photosynthesis at high temperature and radiation. Flowering may start 4–8 weeks after sowing. Pollination is effected by wind but the abundant pollen production causes a high rate of self-pollination. The first seeds mature about 6 weeks after sowing. The plant becomes senescent and stops growing after about 4 months, and subsequently dies. With repeated picking, *Amaranthus tricolor* plants may become some months older.

Ecology Weedy plants of *Amaranthus tricolor* can be found occasionally on cultivated land, flood plains, roadsides and wasteland. Vegetable amaranths, including *Amaranthus tricolor*, grow well at day temperatures above 25°C and night temperatures not lower than 15°C. Shade is disadvantageous except in cases of drought stress. *Amaranthus tricolor* is a vegetable suited for cultivation in the tropics from sea level up to 1000 m altitude and in subtropical areas and warm temperate areas during the summer. It shows a quantitative short-day reaction, but the daylength reaction is not strong. In India, *Amaranthus tricolor* is known as a plant showing a qualitative short-day reaction, requiring 15 hours or less daily light for induction of flowering.
Amaranths like fertile, well-drained soils with a loose structure; on poor soils only modest crops can be produced. The mineral uptake is very high.

Propagation and planting. The seed-weight of *Amaranthus tricolor* is 1200–2900 seeds/g. Growers spare a few vigorous plants at harvest for seed production. Market seed production fields yield 300–600 kg seed per ha in a five-month period. For commercial seed production an isolation distance of 200 m should be respected. In home gardens scattered seed of flowering plants gives rise to new plants. Germination is stimulated by darkness. The seed may be mixed with sand for easier sowing. The common practice is to sow directly, broadcast or in rows with 10–20 cm between the rows, with a seed rate of 2–5 g/m^2. Unlike for *Amaranthus cruentus* and *Amaranthus dubius* Mart. ex Thell., sowing in a seedbed and transplanting is not recommended, the plantlets being too weak. *Amaranthus tricolor* is normally grown as a sole crop on beds. It is also found in intercropping systems with food crops and in home gardens.

Management *Amaranthus tricolor* is fast growing, albeit less so than the more commonly cultivated *Amaranthus cruentus* and *Amaranthus dubius*. Weeds such as pigweed (*Portulaca*) or nut grass (*Cyperus rotundus* L.) may be troublesome. If rainfall is not sufficient, irrigation by sprinkling should be done before the plants start wilting. *Amaranthus tricolor* is much more susceptible to drought than other vegetable amaranths. Watering every day with 6 mm (6 l/m^2) is sufficient. Water shortage

causes early flowering, which reduces the yield and the market quality. Amaranth is a very high consumer of minerals. The mineral uptake of a crop yielding 15 t/ha is about 75 kg N, 15 kg P, 150 kg K, 45 kg Ca and 25 kg Mg. Larger quantities of N and K are easily absorbed as luxury uptake if these elements are abundant. Amaranth responds to high rates of organic fertilizer. In some places it is grown on large quantities (up to 50 t/ha) of almost fresh town refuse, which fulfils its need for minerals. On poor soils, the application of 250 kg/ha of NPK 10–10–20 in addition to 25 t of organic manure is recommended. A split application is recommended during the rainy season. Response to nitrate-N is better than to ammonium-N. Amaranth does not need to be rotated with other crops since no serious soilborne diseases have been observed.

Diseases and pests In general *Amaranthus tricolor* is more susceptible to pests and diseases than the sturdier *Amaranthus cruentus*. The main disease is stemrot caused by the fungus *Choanephora cucurbitarum*. A wider spacing may reduce the rate of infection. Damping-off caused by *Pythium* and *Rhizoctonia* may be serious in seedlings. It is controlled by good drainage. Over-dense sowing should be avoided. Fungicides such as dithiocarbamates have some effect. Some cultivars are quite resistant. In India white rust (*Albugo bliti*) is sometimes serious. In Brazil a serious leaf and stem blight caused by *Phomopsis amaranthophila* occurs. No virus diseases have been reported.

Insects are a more serious problem for amaranth growers. Caterpillars (*Hymenia recurvalis*, *Spodoptera litura*, *Heliothis armigera*) and sometimes grasshoppers are the most harmful pests. The larvae of the stem borer *Lixus truncatulus* may cause much damage, sometimes already in the seedling stage. The basal part of the plant containing the pupae swells and the plant growth is much retarded. Many other insects such as aphids, leaf miners, stinkbugs, mole crickets and mites attack amaranth but generally cause only minor damage. Commercial growers now spray insecticides instead of using the traditional control method of spreading wood ash to dispel insects. Amaranth is not very susceptible to nematode attack.

Harvesting Commercial growers harvest by uprooting or by cutting at ground level. This once-over harvest may be done 3–4 weeks after sowing. Some growers obtain a second harvest 3 weeks later from the regrowth of the smallest plants. Repeated cutting (ratooning) is sometimes practised too; the first cutting about one month after transplanting, and then every 2–3 weeks for a period of one to two months. *Amaranthus tricolor* is less suited to ratooning than other amaranth species.

Yield A commercial grower may harvests 1–1.5 kg/m^2 of an uprooted crop (dry matter content 12%, edible portion 70–80%). The first cutting of a ratooned crop yields about 1.0–1.2 kg/m^2 (edible portion 70–80%), successive cuttings 1–1.5 kg/m^2. Continuous cropping may yield up to 20 kg/m^2 marketable product per year.

Handling after harvest Harvested plants or shoots are bundled, the roots are washed, and the produce is packed for transport to the market. In markets and shops, it is sprinkled with water to keep a fresh appearance. If uprooted, the vegetable can be kept fresh for some days by putting it in a basin with the roots in the water. Amaranth is sold per bunch or by weight.

Genetic resources *Amaranthus tricolor* is present in *Amaranthus* collections at the National Bureau of Plant Genetic Resources (NBPGR), New Delhi (India), at the Rodale Organic Gardening and Farming Research Center (OGFR), Kutztown, United States, and at the Asian Vegetable Research and Development Center (AVRDC) at Tainan, Taiwan. Many national research institutes in Asia have working collections of local cultivars. In Africa *Amaranthus tricolor* is only occasionally cultivated, and the genetic diversity is unclear.

Breeding There are many local types and cultivars of *Amaranthus tricolor*. They are distinguished from each other by plant habit and characters such as leaf form, leaf/stem ratio, growth vigour, resistance to fungal diseases, photosensitivety, succulence and taste. Most cultivars are dark green, others are pale green, some have a large brown-red spot of anthocyane in the centre of the leaf blade, others are completely purple. Breeding work has been performed e.g. in Indonesia, India, Thailand and Taiwan. Many commercial cultivars are available in South and South-East Asian countries, e.g. from East-West Seed Company in Indonesia and Thailand. Cultivar 'Tampala' is adapted to cultivation in southern United States, cultivar 'Lal Sag' is popular in India. Several productive commercial cultivars were developed at Tamil Nadu Agricultural University, Coimbatore, India. Some cultivars are

more suited for pulling, others for clipping. Many cultivars are selected for a high (>2) leaf/stem ratio.

Prospects *Amaranthus tricolor* is recognized as an easy-to-grow, productive, tasty and nutritious vegetable. Research should focus on optimization of cultural practices, especially integrated pest management to avoid pesticide residues, and on breeding for disease resistance. Heterosis effects in crosses between less-related types may be exploited. Selection for low oxalate content will improve the nutritional availability of calcium, iron and zinc.

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Sources of illustration Grubben, G.J.H., 1993a; Townsend, C.C., 1985.

Authors G.J.H. Grubben

AMARANTHUS VIRIDIS L.

Protologue Sp. pl. ed. 2, 2: 1405 (1763).

Family Amaranthaceae

Chromosome number $2n = 34$

Synonyms *Amaranthus gracilis* Desf. ex Poir. (1810).

Vernacular names Green amaranth, local tete, African spinach (En). Amarante verte, épinard vert, épinard du Congo (Fr). Amaranto (Po). Mchicha (Sw).

Origin and geographic distribution *Amaranthus viridis* is possibly of Asian origin but now a cosmopolitan weed in the tropical and subtropical regions of the world, also penetrating far into temperate regions (e.g. in Europe, North America, Asia and Australia). In tropical Africa it is also a widespread and common weed. It is occasionally cultivated (e.g. in Nigeria, Gabon and DR Congo).

Uses *Amaranthus viridis* leaves and young plants (before they come into flower) are occasionally eaten as a cooked vegetable. The plant is also a good cattle fodder and green manure. The leaves are diuretic and purgative, and are used in poultices (fresh or as dried powder) to treat inflammations, boils and abscesses, gonorrhoea, orchitis and haemorrhoids. In Nigeria an infusion of the whole plant is used to purify the blood and the pounded root is applied against dysentery. In Côte d'Ivoire leaf sap is used as an eye wash to treat eye infections and for treating convulsions and epilepsy in children. In DR Congo the sap is said to act as a vermifuge, being effective against filaria, as an emmenagogue and to relieve heart troubles. The leaves are believed to have febrifugal properties. Ash of *Amaranthus viridis* plants is rich in soda and is occasionally used to make soap.

Properties The composition of the leaves of *Amaranthus viridis* is comparable to that of other *Amaranthus* species, e.g. *Amaranthus cruentus* L. The (powdered) leaf contains tannin, reducing sugar and resin. Amasterol (24-methylene-20-hydroxycholest-5,7-en-3β-ol) has been isolated from the roots; this compound has allelopathic effects on lettuce seed germination.

Botany Erect or ascending annual or short-lived perennial herb up to 1 m tall; stem slender, branched, angular, glabrous to sparsely pubescent in upper part with multicellular hairs. Leaves alternate, simple; petiole up to 10 cm long; blade deltoid-ovate to rhomboid-oblong, 2–8 cm × 1.5–6 cm, base shortly cuneate, apex emarginate with small mucro, margin sometimes sinuate, glabrous to pubescent. Inflorescence consisting of agglomerated cymes arranged in slender, axillary or mostly terminal spikes, frequently paniculate, up to 12 cm long, in the lower part of the stem often in dense axillary clusters c. 7 mm in diameter. Flowers unisexual, subsessile, green, male and female intermixed but female ones more numerous; bracts and bracteoles lanceolate-ovate, c. 1 mm long, whitish-membranous; tepals 3, oblong to obovate, 1–1.5 mm long, midrib often thickened above, bent along the fruit; male flowers with 3 stamens; female flowers with superior, 1-celled ovary crowned by 2–3 short stigmas. Fruit a subglobose capsule, c. 1.5 mm in diameter, not or slightly exceeding the perianth, indehiscent, usually strongly wrinkled, 1-seeded. Seed subglobose, slightly compressed, c. 1 mm in diameter, margin acute, glossy black, verrucose or with inconspicuous sculpture. Seedling with epigeal germination; cotyledons lanceolate, c. 12 mm × 2.5 mm.

Amaranthus comprises about 70 species, of which about 40 are native to the Americas. It includes at least 17 species with edible leaves

and 3 grain amaranths. *Amaranthus viridis* is often confused with *Amaranthus blitum* L., but the latter differs in its often more ellipsoid and smooth or slightly wrinkled fruits. It is sometimes also confused with *Amaranthus deflexus* L., a perennial herb with prostrate or ascending stems originating from temperate South America, but now naturalized as a weed in many parts of the world, locally also in tropical Africa (e.g. Kenya, Zimbabwe). In South Africa *Amaranthus deflexus* is sometimes used as a cooked vegetable.

Ecology In Africa *Amaranthus viridis* is a weed growing on disturbed or cultivated land, often around habitations. It flowers and fruits year-round.

Management Although mostly collected from the wild, *Amaranthus viridis* is easily grown from seed like other amaranths. Pigweed mosaic virus causes shorter shoots, roots and inflorescences, smaller leaves and stem diameter, less branching and a reduction of the fresh weight of shoots and roots.

Genetic resources and breeding A collection of amaranths is kept at the Rodale Organic Gardening and Farming Research Center (OGFRC) at Kutztown, Pennsylvania, United States; South-East Asian accessions are kept at the Asian Vegetable Research and Development Center (AVRDC) at Tainan, Taiwan. African cultivars and introductions from OGFRC are kept at the National Horticultural Research Institute (NHR) in Nigeria and African cultivars at the AVRDC centre at Arusha, Tanzania. Indian collections are kept at the National Bureau of Plant Genetic Resources (NBPGR), New Delhi, India. Many national institutes have small working collections of local cultivars. Evaluation and variability studies are needed to reveal the amount of exploitable genetic variation.

Prospects *Amaranthus viridis* is an interesting weed vegetable with a good nutritional value. It certainly deserves more attention to determine wider domestication possibilities and optimum cultivation practices. Its medicinal properties need further investigation as well.

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Authors P.C.M. Jansen

APIUM GRAVEOLENS L.

Protologue Sp. pl. 1: 264 (1753).
Family Apiaceae (Umbelliferae)
Chromosome number $2n = 22$

Vernacular names Celery, leaf celery, stalk celery, celeriac, turnip-rooted celery (En). Céleri, céleri feuille, céleri à couper, céleri-branche, céleri à côtes, céleri-rave (Fr). Aipo hortense, salsão, aipa nabo (Po).

Origin and geographic distribution Celery occurs wild in Europe, the Mediterranean region and in Asia west of the Himalayas. The ancient Greeks and Egyptians already cultivated celery. It was probably first grown as a medicinal plant, later for the leaves as flavouring. Celery has a long history in China, dating back to at least the 6th century AD. Chinese celery most resembles leaf celery. Cultivated celery was recorded in 1623 in France, where plants with a milder taste were selected from wild plants for use as a vegetable. This was the so-called stalk celery with large, swollen petioles. At the same time celeriac with its large edible tuber was selected, probably in Italy. These two types became most important in Western temperate areas. Various types of celery are now grown all over the world. Celery is reported as being cultivated in several Afri-

Apium graveolens – planted

can countries, more commonly in highland regions than in lowlands. In Africa it is occasionally found as an escape or relic of cultivation, e.g. in Eritrea, Ethiopia, Mozambique and Réunion, and more commonly in South Africa.

Uses The most common use of celery is for its thick, succulent leaf stalks that are used, often with a part of the leaf blades, in soups, cooked dishes and salads for the Western style kitchen. Celeriac or turnip-rooted celery is mainly used as a cooked vegetable in stews and soups but is becoming increasingly popular grated as a raw salad. Leaf celery, also called smallage, is chopped and used as garnish and flavouring, either fresh or in dried powdered form. In temperate countries, celery is also grown for its seeds, which yield a valuable volatile oil used in the perfume and pharmaceutical industries. Celery seeds can be used as flavouring or spice either as whole seeds or, ground and mixed with salt, as celery salt. Celery salt can also be made from an extract of the roots. Celery seed aids in the elimination of uric acid and is often used for the relief of symptoms of arthritis, rheumatism and inflammation of the joints. Its diuretic properties assist in relieving fluid retention. Celery seed also relieves pain. Celery has several applications in traditional medicine, particularly as a diuretic and emmenagogue, and against dengue fever and rheumatism.

Production and international trade There is a considerable production and international trade in stalk celery and celeriac among Western countries. In Africa leaf celery and stalk celery are usually grown on small plots for market gardening, whereas celeriac is only rarely grown. No statistical information on areas under production or on market volumes are available.

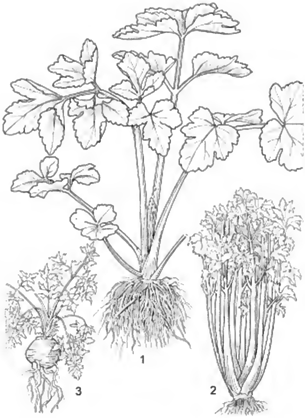
Properties The raw leaf stalk of celery contains per 100 g edible portion (91% of the product as purchased): water 95.1 g, energy 29 kJ (7 kcal), protein 0.5 g, fat 0.2 g, carbohydrate 0.9 g, dietary fibre 1.6 g, Ca 41 mg, Mg 5 mg, P 21 mg, Fe 0.4 mg, Zn 0.1 mg, carotene 50 μg, thiamin 0.06 mg, riboflavin 0.01 mg, niacin 0.3 mg, folate 16 μg, ascorbic acid 8 mg. Celeriac contains per 100 g edible portion (60% of the product as purchased, top and root trimmed, peeled): water 88.8 g, energy 73 kJ (18 kcal), protein 1.2 g, fat 0.4 g, carbohydrate 2.3 g, dietary fibre 5.1 g, Ca 40 mg, Mg 21 mg, P 63 mg, Fe 0.8 mg, Zn 0.3 mg, carotene 26 μg, thiamin 0.18 mg, riboflavin 0.02 mg, niacin 0.2 mg, folate 51 μg, ascorbic acid 14 mg. Celery seed contains per 100 g edible portion (100% of the product as purchased): water 6.0 g, protein 2.9 g, fat 18.1 g, Ca 1770 mg, Mg 440 mg, P 550 mg, Fe 44.9 mg, Zn 5.7 mg (Holland, B., Unwin, I.D. & Buss, D.H., 1991). The nutritional composition of leaf celery (leaf blades and small stalks) per 100 g edible portion (50% of the product as purchased) is: water 92.7 g, energy 84 kJ (20 kcal), protein 1.1 g, fat 0.1 g, carbohydrate 4.5 g, fibre 1.0 g, Ca 87 mg, P 50 mg, Fe 0.9 mg, thiamin 0.03 mg, riboflavin 0.25 mg, ascorbic acid 17 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968).

The characteristic smell of the celery plant is due to the lactone sedanolide (3-butyl-3a,4,5,6-tetrahydrophthalide), sedanenolide (3-butyl-4,5-dihydrophthalide) and related phthalides. These are also the character-impact compounds of the essential oil from celery leaves and seed. The results of tests with mice suggest that phthalides may be effective chemopreventive agents of forestomach cancer. The flavonoid apigenin was also isolated from celery; this compound has vasodilatory action. Celery extracts exhibited hepatoprotective activity in tests with rats. Tests with mice affirmed the use in traditional medicine for painful and inflammatory conditions; extracts showed antinociceptive and anti-inflammatory activities.

The seeds contain a volatile oil and some compounds with antioxidant activity, as well as compounds with mosquitocidal, nematicidal and antifungal activities. Celery plants contain the furanocoumarins bergapten and psoralen, potent photosensitizers which may cause dermatitis in field workers. Celeriac (celery root) is a frequent cause of food allergy, often connected with pollen allergy; the major allergen is the protein api g 1.

Adulterations and substitutes Parsley (*Petroselinum crispum* (Mill.) Nyman ex A.W.Hill) leaves can be used as a substitute for leaf celery, parsley roots as a substitute for celeriac. Parsley is, however, usually considered a condiment rather than a vegetable.

Description Biennial, erect, glabrous herb up to 100 cm tall, with a fusiform to tuber-like fleshy taproot; stem strongly grooved. Leaves alternate, lower ones pinnate, long-petioled, upper ones 3-fid; stipules absent, but distinct sheath present; leaflets deltoid-rhomboid, 2–5 cm × 1.5–3 cm, often deeply 3-lobed, cuneate at base, glossy. Inflorescence a sessile or short-peduncled umbel, terminal or opposite the leaves; primary rays 4–15, rather unequal;



Apium graveolens – 1, habit leaf celery; 2, habit stalk celery; 3, habit celeriac.
Source: PROSEA

involucres and involucels absent; umbellules 6–25-flowered. Flowers bisexual, 5-merous; pedicel 1–5 mm long; calyx teeth obsolete; petals free, ovate to orbicular, c. 0.5 mm long, with inflexed apex, greenish white; stamens free, alternating with petals; ovary inferior, 2-celled, styles 2, divergent. Fruit a broadly ovoid to globose schizocarp, splitting into two 1-seeded parts up to 1.5 mm long, distinctly ribbed. Seedling with epigeal germination; hypocotyl 1–2 cm long, epicotyl absent; cotyledons stalked, blade ovate-oblong, up to 6 mm long, herbaceous.

Other botanical information *Apium* comprises about 30 species, most of which are indigenous in temperate South America. Only a few *Apium* species occur in tropical Africa, and probably only a single one is truly indigenous: *Apium nodiflorum* (L.) Lag. *Apium leptophyllum* (Pers.) F.Muell. ex Benth. is a widespread weed originating from Central America.
Apium graveolens has been subdivided into 4 varieties:
- Var. *graveolens*. Representing the wild type.
- Var. *secalinum* (Alef.) Mansf. Leaf celery, cultivated for the aromatic leaves. It has slender green petioles, and is closest to the wild type.
- Var. *dulce* (Mill.) Pers. Stalk celery, cultivated for its strongly developed, fleshy petioles, which are curved in cross-section and grooved on the external surface, with a distinct joint where the leaflets are attached.
- Var. *rapaceum* (Mill.) Gaudin. Celeriac, grown for the roundish tuber up to 15 cm in diameter, mainly derived from the hypocotyl, but also incorporating part of the taproot and stem. Its flesh is creamy white and firm, although usually softer than carrots.

The latter 3 varieties can better be considered to represent cultivar groups.
Some celeriac cultivars used in East Africa are 'Balder' and 'Giant Prague'. Stalk celery cultivars that have been in use in East Africa for some time are 'Pascal', 'Utah', 'Golden Self-Blanching' and 'Tendercrisp'. The seed company Technisem is now recommending the stalk celery cultivars 'Plein Blanc Pascal', 'Tall Utah' and the heat tolerant 'Elne' with fleshy green stalks; the latter cultivar also performs well in lowland regions of West Africa. East West Seed Company developed leaf celery cultivars for the tropics, with more tender leaves and less thick stalks, called Chinese celery: 'Juji' is a selection for year-round cultivation in tropical lowland, 'Duka' is hardier, especially selected for the rainy season, and 'Safiya' performs best at medium or high elevations.

Growth and development Celery is biennial, but when cultivated for its vegetative parts mostly grown as an annual. Germination and seedling growth are rather slow. Leaf celery is usually direct sown, sometimes transplanted one month after germination; stalk celery and celeriac plants are mostly raised in a nursery and need 2 months to reach a suitable size for transplanting. During the vegetative phase, the aboveground parts of the plant mainly consist of leaves, the stem being very short. The stem elongates after vernalization, ending in compound umbels. Celery flowers are mainly cross-pollinated. The root system is quite restricted and superficial. Crop duration depends on type, cultivar, and market preference. Harvesting of early cultivars of leaf celery starts 55–60 days after direct sowing or 40–50 days after transplanting one-month-old nursery plants, whereas late cultivars are harvested from 3 months after direct sowing. Transplanted stalk celery is harvested 3–4 months and celeriac 4–5 months after transplanting.

Ecology The wild type of *Apium graveolens* is a halophilous marsh plant, which explains the high water needs and good salt tolerance of cultivated types. Types of European origin are usually cultivated in the tropics at higher elevations. They are adapted to areas with monthly mean temperatures of 15–21°C. Exposure at the five-true-leaf stage to 5–10°C for a minimum of 10 days causes bolting. Consequently, premature flowering of these types is seldom a problem in the tropics. Asiatic tropical cultivars of leaf celery, however, start bolting easily when exposed to temperatures below 20°C. Celery demands a moist, pervious, fertile, if possible slightly saline soil, with pH 6.0–6.8, well supplied with organic matter.

Propagation and planting Celery seed is almost entirely produced in temperate areas and imported in Africa, although it is possible to harvest seed of tropical types of leaf celery. In the highlands of East Africa it may be possible to produce seed from the heat-tolerant types of stalk celery. The weight of 1000 seeds is 0.3–0.5 g. Celery seed is broadcast on a nursery bed or, mostly for leaf celery, sown in rows directly in the field. It is slow to germinate. After some weeks, the small and delicate seedlings emerge and should be well protected with a layer of long grass or similar cover. Light shading is beneficial, especially in lowlands. To reduce the germination period required some farmers soak the seeds for one or two days prior to sowing. It is even better to mix the fine seeds with sand and keep this mixture moist until the first signs of white root tips become visible. This pre-germinated mixture should then be sown, and the seedbed should be kept well watered until the seedlings have clearly emerged. The nursery stage may take one month for leaf celery to 6–10 weeks for stalk celery and celeriac. Seedlings are planted at a spacing of 30 cm in the row and 40 cm between rows. Celery responds well to organic manure incorporated into the plantbed prior to planting.

Management Once seedlings are well established, earthing up is recommended as it is not possible to plant the small seedlings at the required depth of about 4 cm. Older cultivars of stalk celery required blanching, but this is no longer needed for present-day cultivars, although many people still believe that blanched stems taste sweeter. In case blanching is desired, plants should be earthed up with approximately 15 cm of soil or the leaf stalks should be tied together about 3 weeks prior to harvesting. Plants must be allowed to grow rapidly to obtain the desirable quality with succulent leafstalks; therefore regular irrigation is essential. Large amounts of nutrients are also needed for a good celery crop. The removal of nutrients in 20 t/ha of stalk celery is estimated at 75 kg N, 17 kg P, 140 kg K, 36 kg Ca and 11 kg Mg. Celery is susceptible to physiological disorders, which can usually be remedied by applying 10–20 kg/ha of borax and 100 kg/ha of magnesium sulphate. Boron deficiency is especially prominent in soils with a high pH. Cultivation must be superficial in order to avoid damaging the roots. Mulching the soil surface helps to retain moisture and to smother weeds.

Diseases and pests A serious disease under humid conditions is late blight caused by *Septoria apiicola*. It is also referred to as celery rust and is characterized by many small pale brown spots with dark centres. Proper aeration is important and during the rainy season a wider spacing is required in comparison to the dry season. Early blight, caused by *Cercospora apii*, can also become problematic. Both fungi are seedborne, and therefore seed from a reliable source should be used. They can also survive on plant refuse in the soil. Seed treatment and crop rotation are recommended practices. *Erwinia carotovora*, a bacterium causing soft rot of the petiole, is also soilborne and requires crop rotation. Damping-off of seedlings caused by species of *Pythium*, *Sclerotium* and *Rhizoctonia* is common. *Rhizoctonia solani* is also reported to cause lesions and rot of the petioles.

Few specific pests have been reported on celery, but polyphagous insects such as aphids, spider mites, leafhoppers, whiteflies and leafminers may affect the crop.

Harvesting Leaf celery is harvested once-over by uprooting or by cutting at ground level, or is ratoon-harvested by cutting about 5 cm above ground level, with several cuttings at 3-week intervals. Stalk celery is usually cut at ground level as a whole plant. For home consumption, people may only harvest a few stalks per plant at a time. Commercial growers often tie the stalks together, leaving the tender young stalks well covered. Celeriac is harvested by uprooting.

Yield Leaf celery can produce up to 20 t/ha. The yield of stalk celery can reach 20 t/ha or more, depending on soil fertility, farm management and climatic conditions. In Europe, yields of up to 50 t/ha for both stalk celery and

celeriac have been obtained, but in the tropics the yield potential is much lower.

Handling after harvest The harvested product should be removed from the field as soon as possible, washed, sorted, packed and transported to the market. Stalk celery can be stored for about a month at a temperature near 0°C at high humidity. It should be isolated in storage, because it readily absorbs flavours from other produce. Celeriac can be stored more easily. In some Western countries, much stalk celery is processed by canning.

Genetic resources Important germplasm collections are maintained at the Research and Plant Breeding Institute for Vegetables in Olomouc, Czech Republic, the National Bureau of Plant Genetic Resources, New Delhi, India, the Vavilov Institute of Plant Industry, Petersburg, Russia, the Institute of Horticultural Research, Wellesbourne, United Kingdom, and at the Northeast Regional Plant Introduction Station, Geneva, New York, United States.

Breeding The main breeding objectives for celery are to improve disease resistance and tolerance of high temperatures, for stalk celery the tenderness of the petioles and the self-blanching character.

Prospects Celery is currently not an important commercial vegetable in Africa and since most produce is purchased by Asian and Western people, market opportunities are not likely to increase considerably, unless a change in food habits takes place. The markets for leaf and stalk celery in the cities in francophone West Africa offer better opportunities. It seems likely that more improved cultivars for tropical conditions will soon become available.

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Sources of illustration Susiarti, S. & Siemonsma, J.S., 1993.

Authors R.R. Schippers

Based on PROSEA 8: Vegetables.

ARTANEMA LONGIFOLIUM (L.) Vatke

Protologue Linnaea 43: 307 (1882).

Family Scrophulariaceae

Synonyms *Artanema sesamoides* (Vahl) Benth. (1835).

Origin and geographic distribution *Artanema longifolium* is found in tropical Africa from Liberia to Cameroon, DR Congo, Uganda and Tanzania. It occurs also in India and throughout tropical South-East Asia.

Uses In Nigeria and Tanzania the leaves of *Artanema longifolium* are collected from the wild and eaten as a vegetable.

Properties An aqueous extract of *Artanema longifolium* is a component of Ayurvedic medicines used against inflammations of the skeleto-muscular system. It is also used against nausea.

Botany Erect, often branched herb up to 90 cm tall with sharply quadrangular to almost 4-winged, fleshy, hollow stem. Leaves opposite, simple, subsessile; blade lanceolate, 3.5–25 cm × 1–9 cm, margin entire to slightly serrate, glabrous but rough above because of small bristles. Inflorescence a terminal, erect, many-flowered, peduncled raceme up to 40 cm long. Flowers bisexual, zygomorphic; pedicel up to 1 cm long; calyx 5-lobed almost to the base, lobes ovate-oblong, 3–10 mm long, overlapping at anthesis, persistent in fruit; corolla deep red-purple, glandular hairy, with wide tube and 2 lips 1–3 cm long, upper lip erect, broadly rounded, emarginate, lower lip patent, rounded, 3-fid; stamens 4, didynamous, filaments with a disk-like appendage; ovary superior, 2-celled, style filiform, stigma 2-lobed. Fruit a subglobose capsule up to 1 cm in diameter, many-seeded. Seeds ellipsoid-globose, yellow-brown, tuberculate. Seedling with epigeal germination; hypocotyl 3–7 mm long, epicotyl very short; cotyledons rhomboid, 4–5 mm long, leafy.

Artanema is poorly known; it comprises about 4 species and is distributed in tropical Africa and Asia. It has been classified in tribe *Gratioleae*, which is highly diverse and split up in recent molecular-systematic studies. *Artanema* was not included in these studies.

Ecology *Artanema longifolium* occurs in forest and scrub vegetation, in humid and swampy localities, and is common along rice fields and watercourses, and in soggy grassland, up to 400 m altitude.

Genetic resources and breeding *Artanema longifolium* is widespread in tropical

Africa and Asia and not in danger of genetic erosion.

Prospects *Artanema longifolium* will remain a minor leaf vegetable. Its nutritional composition needs investigation. With its deep red-purple flowers it is decorative and seems to have potential as an attractive garden ornamental.

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ASPARAGUS FLAGELLARIS (Kunth) Baker

Protologue Journ. Linn. Soc. 14: 614 (1875).

Family Asparagaceae

Synonyms *Asparagopsis flagellaris* Kunth (1850). *Asparagus pauli-guilelmi* Solms-Laub. (1867).

Vernacular names Wild asparagus (En). Asperge sauvage, asperge rampante, piège de la hyène (Fr).

Origin and geographic distribution *Asparagus flagellaris* is widespread in tropical Africa. It has been much confused with *Asparagus africanus* Lam., which occurs in East and southern Africa, but it is not clear whether the latter species can also be found in West Africa.

Uses The uses described here refer to both *Asparagus flagellaris* and *Asparagus africanus*, which are probably used indiscriminately. The young shoot-tips ('spears') are fleshy and edible, resembling the asparagus of commerce harvested from *Asparagus officinalis* L. In Tanzania the young shoots are dug up, peeled and chewed to quench thirst and hunger, especially by children and herdsmen. Uses as a vegetable, fresh or boiled, have been reported from Gabon and southern Africa, but are probably common in several other countries. The fleshy root tubers are edible after several hours cooking. The fruits are sucked out by children in Uganda and Tanzania, especially during famine periods.

The branchlets (cladodes) are the main ingredient of a medicine to combat guinea-worm and of an ointment for hair growth. In the Central African Republic they are eaten to combat stitch. The branchlets are used as a wound medicine in Kenya, to treat earache in Tanzania, and in many countries to treat eyesight troubles. The roots have a variety of medicinal uses. In Senegal and Tanzania they are added to food or baths for treating syphilis, gonorrhoea and other sexually transmitted diseases. In Senegal macerated root is gargled against throat troubles, and in East Africa the roots are chewed for the same purpose. In Ethiopia pounded branches mixed with butter are used as an ointment for the treatment of haemorrhoids. An embrocation is used in Senegal against rheumatism. A hot water infusion is used in Zimbabwe to arrest diarrhoea. In Côte d'Ivoire, Burkina Faso and Nigeria a root macerate is used against earache, in Nigeria for the treatment of haematuria, in Kenya for curing coughs, in Côte d'Ivoire and Tanzania against schistosomiasis and in Tanzania (Teita tribe) as an ingredient of a complicated technique for the treatment of bubonic plague. In East Africa the branchlets, stems or roots are pounded, soaked in water and the infusion drunk 2–3 times a day for the treatment of mental disturbance.

The Maasai in Kenya boil the roots, add milk and give it to women immediately after childbirth to release the afterbirth. In Burkina Faso a decoction of the roots is used to promote healing of the umbilicus of the newborn by external application and in small quantity by draught. In the Central African Republic a root decoction is taken by women wishing to conceive. The roots and branchlets are ingredients of arrow-poison. In Tanzania, seeds are swallowed to prevent eye diseases.

Wild asparagus is used throughout Africa for a wide variety of ailments of cattle. It is used in several ceremonies and initiation rituals. In Tanzania it is planted as an ornamental. In a number of countries, the wiry stems are used for preparing traps and snares for small animals, and for making cord. The woody stem parts are used for making pencils in Sudan.

Properties There is no information on the chemical composition of *Asparagus flagellaris*, but a few studies have been performed on *Asparagus africanus*. Small amounts of an alkaloid have been found in the branchlets of Nigerian material, and the cardiac glycosidal activity has been tested and reported negative. Steroidal saponins were isolated from the roots of *Asparagus africanus*, including 2 monodesmosidic spirostanosides and a bisdesmosidic furostanol glycoside. Antiprotozoal activity has been reported for some compounds isolated from the roots of *Asparagus africanus*, including the sapogenin muzanzagenin and the lig-

nan (+)-nyasol. These compounds inhibited the growth of *Leishmania major* promastigotes and *Plasmodium falciparum* schizonts.

Botany Erect shrub up to 2 m tall, with swollen root tubers; branches smooth or with spines 2–4 mm long, ultimate branchlets (cladodes) in whorls of 1–8, leaf-like, up to 2(–6) cm long, stiff. Flowers axillary, 1–2 together, bisexual, regular, 6-merous, white to purple; pedicel 3–8 mm long; perianth segments 2.5–3 mm long, stamens fused to perianth segments; ovary superior, 3-celled, style c. 1 mm long, 3-branched. Fruit a globose berry 5–7 mm in diameter, orange-red at maturity, usually 1-seeded. Seed globose, c. 4 mm in diameter, rugose.

Asparagus comprises about 200 species. Many more than 100 of these occur in Africa. *Asparagus flagellaris* has been much confused with *Asparagus africanus*, which differs in its usually shorter cladodes and its fascicles of 2–10 slightly larger flowers. Taxonomic studies are still needed to unravel the status and distribution of these two species.

Other wild African *Asparagus* species of which the spears are also eaten include *Asparagus aethiopicus* L., *Asparagus laricinus* Burch., *Asparagus schroederi* Engl., *Asparagus setaceus* (Kunth) Jessop and *Asparagus suaveolens* Burch.

Ecology *Asparagus flagellaris* can be found in woodland, savanna and wasteland, up to 1800 m altitude.

Management Currently, the various plant parts of wild asparagus are collected from the wild. The plants are available to anyone needing them and are not especially protected or managed by the local population. In Tanzania the shoots are collected during the rainy season, the fruits during the dry spells in June–July and December. Wild asparagus can be propagated by seed and by root suckers. The seed has orthodox storage behaviour and can be stored for long periods. In good soil *Asparagus flagellaris* can be grown to produce thick succulent shoots.

Genetic resources and breeding *Asparagus flagellaris* is quite common in its natural range of distribution, and not in danger of genetic erosion. No collections are known for the purpose of genetic conservation or improvement.

Prospects The spears of *Asparagus flagellaris* or other wild *Asparagus* species are not marketed. Currently, the potential of wild asparagus seems limited, due to the high fibre content of the spears. Commercial asparagus production is based on the common asparagus, *Asparagus officinalis* L., but *Asparagus flagellaris* seems to have potential for genetic improvement. The use of fruits will remain of local importance only, but medicinal uses of the plant may be exploited commercially and deserve further research attention, considering the proven activity of many *Asparagus* compounds.

Major references Baerts, M. & Lehmann, J., 2002a; Burkill, H.M., 1995; Dalziel, J.M., 1937; Kerharo, J. & Adam, J.G., 1974; Watt, J.M. & Breyer-Brandwijk, M.G., 1962.

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Authors W.J. van der Burg

ASPARAGUS OFFICINALIS L.

Protologue Sp. pl. 1: 313 (1753).

Family Asparagaceae

Chromosome number $2n = 20, 40$

Vernacular names Asparagus (En). Asperge (Fr). Espargo hortense (Po).

Origin and geographic distribution The origin of asparagus is believed to be the eastern Mediterranean region. However, it grows wild in Europe, the Caucasus and western Siberia. It is naturalized in the Americas and New Zealand, and occurs now worldwide as a crop plant, in Africa mainly in the subtropics. In tropical Africa, it is restricted to high elevation areas in East and southern Africa, but occasionally occurs elsewhere as experimental planting or for own use, e.g. in Rwanda and Ethiopia.

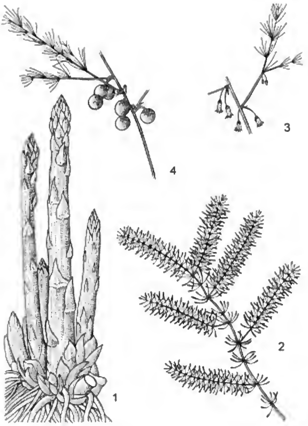
Uses The major product of asparagus are the tender young expanded shoots (spears) which are eaten lightly cooked. The spears are also processed either by canning (or bottling) in brine or by deep-freezing. They are harvested prior to emergence as white asparagus, or after emergence when 18–25 cm tall as green asparagus. Green spears should be all green and white spears all white, but harvest of the in-between stage is also practised. It is normal to peel the white spears prior to cooking, whereas the green ones are normally eaten unpeeled

and only the lower fibrous part of the spears in the in-between stage is peeled.
The foliage of asparagus is occasionally used in flower arrangements.

Production and international trade There are about 255,000 ha of asparagus grown worldwide, equally divided between white and green, with an increasing trend towards the production of green, due to lower harvesting costs. Production predominates in Asia (102,000 ha, with China 90,000 ha), Europe (61,000 ha, with Spain 17,000 ha), North America (51,000 ha, with the United States 34,000 ha) and South America (29,000 ha, with Peru 20,000 ha). Africa (4,000 ha) and Australasia (7,000 ha) are relatively unimportant, although both regions have an important role in providing northern hemisphere markets with out of season fresh asparagus. In Africa asparagus is mainly grown in southern Africa (South Africa, Lesotho) and North Africa (Tunisia), whereas in tropical Africa it is found in the highlands of eastern Africa (Kenya, Uganda, Zimbabwe). The world price fluctuates tremendously, depending on whether the produce is for fresh use or for processing, and also on the time of the year, but tends to be about 1.0 US$/kg. Asparagus production for export is attractive for countries with cheap labour, e.g. Uganda and Kenya, which are able to harvest asparagus for fresh export during periods of low production in Europe.

Properties The composition of white asparagus, per 100 g of raw edible portion (75% of harvested product) is: water 91.4 g, energy 103 kJ (25 kcal), protein 2.9 g, fat 0.6 g, carbohydrate 2.0 g, fibre 1.7 g, Ca 27 mg, Mg 13 mg, P 72 mg, Fe 0.7 mg, Zn 0.7 mg, carotene 315 µg, thiamin 0.16 mg, riboflavin 0.06 mg, niacin 1.0 mg, folate 175 µg, ascorbic acid 12 mg (Holland, B., Unwin, I.D. & Buss, D.H., 1991). Green asparagus scores higher in micronutrients (Fe 1.5 mg, ascorbic acid 48 mg) than white asparagus. The characteristic flavour of asparagus is due to sugars and bitter components. The key olfactory component is dimethyl sulphide, a degradation product of the amino acid S-methyl methionine.

Description Dioecious perennial herb with climbing or erect stems up to 2 m tall, and robust woody rhizome comprising a number of bud clusters and many long (1.5–2 m) unbranched, fleshy storage roots; stem fleshy when still underground, aboveground strongly branched, ultimate branchlets (cladodes) fine, needle-like, green and leaf-like, 1–3 cm long.



Asparagus officinalis – 1, rhizome with young shoots; 2, sterile shoot; 3, flowering shoot; 4, fruiting shoot.
Source: PROSEA

True leaves reduced to minute, bract-like, triangular, brownish, prickly scales, with 3–6 cladodes in the axils. Flowers solitary or in pairs in the leaf-axils, unisexual, small, tubular-campanulate, pendulous, 6-merous, greenish yellow; tepals shortly united at base, 6–8 mm long in male, 4–6 mm in female flowers; male flowers with free stamens inserted near the base of tepals and a rudimentary ovary; female flowers with superior, 3-celled ovary, short style, 3-lobed stigma and rudimentary stamens. Fruit a globose berry up to 1 cm in diameter, red, 1–6-seeded. Seeds rounded, with a flattened side, black.

Other botanical information *Asparagus* comprises about 200 species. Many more than 100 of these occur in Africa, and most have been considered as belonging to a separate genus *Protasparagus* on the basis of bisexual flowers usually in fascicles or racemes, and globose seeds. However, species with intermediate characteristics occur, and *Protasparagus* can best be included in *Asparagus*. Some other species have been placed in another genus,

Myrsiphyllum, mainly differing in cohering stamens, but this genus is also included in *Asparagus*, although usually distinguished as a subgenus. Some wild *Asparagus* species are used in a similar way as *Asparagus officinalis*.

Growth and development Germination is slow, with the optimum temperature being 25–30°C. Initially a single shoot and a single root develop, but once the first shoot has fully expanded, a second shoot develops from the junction of the initial shoot and the root. This is the origin of the primary bud cluster, but in time secondary bud clusters develop in the axils of some of the primary buds. Normally each bud produces two storage roots at about the time that the bud develops into a shoot. Apical dominance within each bud cluster is strong, and the next bud in the cluster does not normally develop until the previous one is fully developed into a shoot (or the spear is harvested). Flowering starts already in the first year and is continuous. The plants are insect-pollinated.

In the humid tropics the plants remain green and never go dormant. In temperate climates the aerial parts senesce during autumn, and growth continues the following spring as the rhizome buds form shoots. In the arid tropics dormancy can be induced by withdrawing irrigation. Under such circumstances production can be programmed for any time of the year. Because the spears from rhizome buds comprise the marketable yield, it is necessary to establish a large pool of stored food reserves, mainly long chain fructans, in the swollen roots before the start of harvesting. It is therefore general practice not to harvest until two years after planting, and to slowly increase the harvest period from 3–4 weeks to 10–12 weeks per year from the third to the fifth year. Senescence of asparagus in the tropics starts earlier than in temperate areas due to the absence of dormancy. In western Europe, plants of over 100 years of age have been reported, although it is normally not economic to harvest longer than 10–15 years. In the tropics the crop starts to decline fast and becomes uneconomic after 6–8 years, and in lowland areas already after 3–4 years. Once the old asparagus plants have been removed, the same field cannot be used for new asparagus plantings for tens of years, probably because the remaining tough old roots contain phytotoxic compounds and are infected with *Fusarium*.

Ecology Asparagus has no daylength response. Photosynthetic activity appears to increase up to 300 W/m^2 PAR (Photosynthetically Active Radiation) as in most C_3 plants. The optimum temperature for dry matter accumulation is 25–30°C, but the optimum temperature for the accumulation of food reserves in the roots may be slightly lower. A high relative humidity is a distinct disadvantage due to foliage diseases. The crop can be successfully produced at low altitudes even in the tropics, though yield and spear quality are not as high as at higher altitudes. Absence of frost during the growing season is important. Deep well-drained sandy loams or volcanic soils are preferable. Especially for white asparagus a light sandy soil is preferred, whereas for green asparagus the soil texture may be heavier. Asparagus appears to be able to grow in a wide range of pH, though 5.8–6.5 is optimum.

Propagation and planting Propagation is primarily by seed. The weight of 1000 seeds is 25–40 g. The import of one-year old rhizomes (crowns) of superior western European hybrid cultivars for large-scale asparagus production in the tropics has been economically disastrous in many cases because the initial investment is too high and the yield capacity and lifespan much lower than in a temperate climate. Besides, this practice increases the risk of the introduction of new pests and diseases. It is recommended that seedlings be raised in situ, which is the normal practice of smallholders. Because asparagus is a long-term crop, the choice of a cultivar is critical; recommended are 'Lucullus' for white and 'Jersey Giant' for green asparagus.

Seed is sometimes sown directly in the final growing site, but more commonly in a field nursery. Production of seedlings in containers under protective cultivation is becoming increasingly important with the higher costs of genetically improved seed. In the nursery, seeds are sown at distances of 15 cm in the row and 35 cm between rows. A nursery of about 100 m^2 needs 0.8–1.0 kg seed, to produce 15,000–25,000 suitable seedlings (crowns) for transplanting. In temperate climates 1-year-old crowns in the dormant stage are uprooted early in spring for planting in the field; in the tropics transplanting is done much earlier, after about 8 months. Plant spacing in the field is normally 1.8 m between the rows and 0.3 m in the row (18,000 plants/ha) for white asparagus production, and 1.5 × 0.3 m (22,000 plants/ha) for green asparagus production. Planting is in 15–20 cm deep furrows, the crown buds pointing up and the roots spread

out. There is increasing interest in vegetative propagation, using tissue culture methods to clone elite plants, but this method is expensive and still in the experimental stage.

Management An adequate supply of nutrients, particularly nitrogen, phosphate, magnesium and potassium, is recommended. For a high yielding crop of about 5 t/ha/year, the annual fertilizer application could be, depending on the soil condition, 100 kg N, 35 kg P, 80 kg K and 60 kg Mg. Before the beginning of the harvest the rows need to be earthed-up into raised beds of up to 50 cm in height with soil from between the rows. Good control of weeds is essential, not only to reduce competition, but also to enable the young spears to be seen at harvest. Staking is sometimes done in the tropics when using the 'mother fern' system (see under Harvesting). The only pruning in the tropics might be to remove the tops of the highest shoots to reduce wind damage. Irrigation requirements depend on rainfall, but because the crop is deep-rooted it is not normally considered important except in arid areas.

Diseases and pests In the humid tropics the major diseases are those attacking the stems and foliage, namely *Stemphylium botryosum*, *Cercospora asparagi* and *Phoma asparagi*. Control is by regular spraying with fungicides (e.g. Mancozeb). Some cultivars developed in New Jersey (United States) appear to have some resistance to these diseases. *Fusarium oxysporum* is a major problem in all climates, and appears to be related to excessive harvesting. *Fusarium* as well as *Phoma* can also be kept under control with good drainage and a balanced fertilizer application.

Harvesting In temperate climates the young spears are harvested in spring for a period of up to 12 weeks, starting in the second year after planting. After the harvest period, the foliage is allowed to grow to replenish the stored reserves in the roots for next year's crop. In tropical climates, harvesting is usually at any time of the year, using the 'mother fern' or 'mother stalk' growing system, in which (once a plant is well established) 3–5 mature photosynthesizing shoots are maintained, while newly developed spears are harvested at the appropriate stage. For green asparagus, spears are cut with a knife at (or just below) ground level when they are about 18–25 cm tall. For white asparagus the spears are cut with a long-bladed knife just above the rhizome when they emerge through the soil surface.

Yield Worldwide the average yield is 3 t/ha per year because of the long period of establishment, but yields from established crops are about 3.6 t/ha in average. In Western countries fields in full production (4–10 years) yield up to 6 t/ha. In arid subtropical climates, where it is possible to harvest 3 crops every two years, yields can be as much as 15 t/ha/year, but the crop duration is shorter than in cool climates. White asparagus yields 10–25% more than a comparable green asparagus crop, because the spears are thicker, and are harvested closer to the rhizome.

Handling after harvest The spears are washed, cut at equal length (between 15 and 22 cm), sorted and packed for marketing. Asparagus spears have a high respiration rate and therefore deteriorate rapidly after harvest. They should be removed from the field as soon as possible after harvest and then stored at high humidity and 2°C (for up to 4 weeks for white asparagus; green asparagus has a much shorter shelf life and can be stored for only about a week).

Genetic resources Germplasm collections of *Asparagus officinalis* cultivars are held at the Crops and Food Research Institute, Lincoln, Canterbury, New Zealand, and at the USDA Northeast Regional Plant Introduction Station, Cornell University, Geneva NY, United States.

Breeding In Europe and America, many cultivars of *Asparagus officinalis* exist, but cultivars especially selected for the tropics are lacking and local plantings from farmers' seed, resulting from old seed imports, are very heterogeneous. Major breeding objectives are related to the development of improved cultivars for disease resistance, yield and quality. Appearance and low fibre content are particularly important in white asparagus. In Europe, breeding efforts are directed towards the production of 'super male' hybrid cultivars with big spears of uniform quality. Male plants live longer and yield better than female ones. In general these hybrids are vigorous and early producing but susceptible to diseases and less suitable for the tropics than the traditional old open-pollinated cultivars such as 'California 500', 'Mary Washington', 'Lucullus', 'Violette d'Argenteuil' or 'Jersey Giant'.

Prospects There is increasing interest from affluent countries in obtaining fresh asparagus year-round. This asparagus is obtained from northern and southern hemisphere sources during the appropriate spring periods, but could be supplied from the (highland) tropics

during the remaining 6 months of the year. With the increasing interest in fresh rather than processed vegetables, the potential for this crop in the tropics appears good, also because of the low labour costs. The major challenge is to develop cultivars adapted to the tropics, and the appropriate technology for production in the humid tropics through the correct choice of site (high or medium altitude) and harvesting strategy. Other priorities are the control of foliage and soil diseases and the establishment of a sound post-harvest and transportation infrastructure.

Major references Benson, B.L., 1999; Nichols, M.A., 1991; Nichols, M.A., 1993; Robb, A.R., 1984; Uragini, A., 2002.

Other references Holland, B., Unwin, I.D. & Buss, D.H., 1991; Hung, Lih, 1980; Messiaen, C.-M., 1989; Rubatzky, V.E. & Yamaguchi, M., 1997; Standhardt, D. & Kecke, S., 1997; Tindall, H.D., 1983.

Sources of illustration Nichols, M.A., 1993.

Authors M.A. Nichols
Based on PROSEA 8: Vegetables.

ASTRAGALUS ATROPILOSULUS (Hochst.) Bunge

Protologue Mem. Acad. Sci. St.-Petersb., Ser. 7, 15(1): 4 (1869).

Family Papilionaceae (Leguminosae - Papilionoideae, Fabaceae)

Synonyms *Astragalus abyssinicus* Steud. ex A.Rich. (1847).

Origin and geographic distribution *Astragalus atropilosulus* occurs from Sudan and Eritrea south to northern South Africa, extending west into the extreme east of DR Congo. It is also found in Yemen and southwestern Saudi-Arabia.

Uses In Malawi the cooked leaves are eaten as a side dish, sometimes mixed with leaves of *Solanum nigrum* L. In Kenya a decoction of the roots is added to hot milk and given to women with uterine pains after childbirth.

Properties Phytochemical analysis of the whole plant showed the presence of alkaloids, flavonoids, tannins, volatile oils and sterols/triterpenes. An ethanolic extract produced a decrease in heart contractions and a fall in blood pressure in rabbits, neuromuscular blocking activity in rats and frogs, and hypernatraemia in rats.

Botany Erect, perennial herb. Leaves alternate, up to 25 cm long, imparipinnate with 11–51 leaflets; stipules large, leaf-like, entire, broadly triangular-ovate; rachis nearly glabrous, sometimes pubescent; leaflets opposite, narrowly elliptical or lanceolate, up to 3 cm × 1.5 cm, apex obtuse. Inflorescence a many-flowered raceme; bracts linear, whitish. Flowers bisexual, papilionaceous, 5-merous; calyx tube 1.5 mm long, upper teeth 0.5 mm long, lower teeth up to 2 mm long; corolla purplish, white or yellow, with standard up to 1.3 cm long. Fruit a lanceolate pod up to 4 cm × 7 mm.

Astragalus comprises about 2000 species and is mainly north temperate in distribution, with the largest number of species in western and central Asia. A few species are known in northern Africa from dry areas. In the more humid highlands of Africa *Astragalus* is represented by a single variable species, *Astragalus atropilosulus*, in which several subspecies and varieties have been distinguished.

Ecology *Astragalus atropilosulus* is found in upland grassland and scrub vegetation, along streams, forest margins and in disturbed habitats, at 800–3800 m altitude.

Genetic resources and breeding A few accessions of *Astragalus atropilosulus* from Ethiopia, Kenya and Zimbabwe are held in genebanks in Ethiopia, Kenya, Australia and Colombia. The variation present in the species is not likely to have been captured in these collections. Even so, as *Astragalus atropilosulus* is widely distributed and common it is not likely to be threatened by genetic erosion.

Prospects As a vegetable *Astragalus atropilosulus* is likely to remain of some importance only locally.

Major references Gillett, J.B., 1964; Gillett, J.B., Polhill, R.M., Verdcourt, B., Schubert, B.G., Milne-Redhead, E., & Brummitt, R.K., 1971; Kokwaro, J.O., 1993; Pope, G.V., Polhill, R.M. & Martins, E.S. (Editors), 2003; Williamson, J., 1955.

Other references Al-Yahya, M.A., Mossa, J.S., Al-Badr, A.A., Tariq, M. & Al-Meshal, I.A., 1987; Thulin, M., 1989; Wenninger, J., 1991.

Authors C.H. Bosch

ASYSTASIA GANGETICA (L.) T.Anderson

Protologue Thwaites, Enum. pl. zeyl.: 235 (1860).

Family Acanthaceae

Chromosome number $2n = 26, 52$

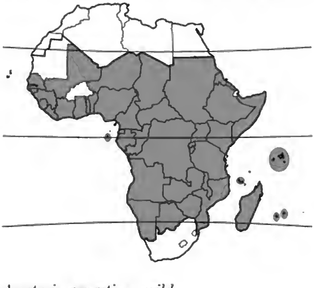
Synonyms *Asystasia coromandeliana* Nees (1832).

Vernacular names Tropical primrose, Chinese violet (En). Herbe le rail, mange-tout, herbe pistache, pistache marron (Fr). Asistasía branca (Po). Fuchwe, mtikini, kichwamangwo (Sw).

Origin and geographic distribution *Asystasia gangetica* is native in tropical Africa, Arabia and tropical Asia, but has been introduced in many other tropical regions, where it often naturalized. It occurs throughout tropical Africa.

Uses *Asystasia gangetica* is locally used as a potherb and leafy vegetable, mainly in times of scarcity. In Kenya and Uganda it is locally a popular vegetable, mixed with beans and groundnut or sesame paste. It is also often prepared in a mix with other leafy vegetables. *Asystasia gangetica* is sometimes promoted as a cover plant in orchards because it checks erosion and prevents infestation by noxious weeds, and because it attracts bees to the orchard. Because of its ability to grow under shade and its high nutritive value, *Asystasia gangetica* is used as a forage for cattle, goats and sheep in South-East Asia; it is either grazed or cut for stall feeding. Excessive consumption by sheep can result in bloat.

In Africa an infusion of the plant is used to ease pain during childbirth, and the sap is applied to sores, wounds and piles, and in embrocations to treat stiff neck and enlarged spleen in children. Powdered roots are considered analgesic and used in treating stomach-ache and snakebites. A leaf decoction is used as analgesic and to treat epilepsy and urethral discharge. In Nigeria the leaves are used to treat asthma. In India the sap is applied to swellings; it is also used as a vermifuge and to treat rheumatism. In the Moluccas (Indonesia) the juice, together with lime and onion juice, is recommended for dry coughs with an irritated throat and discomfort in the chest. In the Philippines the leaves and flowers are used as an intestinal astringent. In Tanzania plants are pounded with water to make a wash against fleas for young animals. *Asystasia gangetica* is occasionally planted as an ornamental.

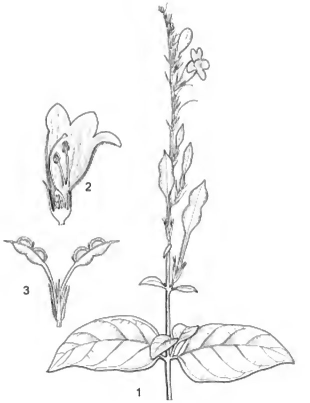


Asystasia gangetica – wild

Properties The nutritional composition of *Asystasia gangetica* leaves per 100 g edible portion is: water 82.6 g, energy 234 kJ (56 kcal), protein 3.7 g, fat 1.2 g, carbohydrate 10.4 g, Ca 226 mg, P 30 mg, Fe 4.7 mg, carotene 6250 μg, thiamin 0.19 mg, riboflavin 0.21 mg, niacin 1.0 mg, ascorbic acid 42 mg (Leung, W.-T.W., Butrum, R.R. & Chang, F.H., 1972). Extracts of *Asystasia gangetica* have shown analgesic and anti-asthmatic properties in pharmacological tests.

Adulterations and substitutes *Asystasia mysorensis* (Roth) T.Anderson is used as a substitute for *Asystasia gangetica*, as are several *Justicia* species.

Description Perennial herb, with usually ascending, branched, quadrangular stem up to 2 m long, often rooting at the lower nodes. Leaves opposite, simple; stipules absent; petiole 0.5–6 cm long; blade ovate to lanceolate, 3–8(–13) cm × 1.5–4.5(–7) cm, base cuneate to cordate, apex acuminate or acute, margin entire, glabrous to sparsely pubescent, with 4–6 lateral veins at each side of the midrib, provided with cystoliths. Inflorescence a terminal raceme up to 25 cm long, with flowers directed to one side. Flowers bisexual, slightly zygomorphic, 5-merous; pedicel up to 3 mm long; calyx with lanceolate lobes 4–10 mm long; corolla funnel-shaped, up to about 2.5(–4) cm long, usually white with purplish spots inside lower lobe, with rounded lobes c. 1 cm wide, lower lobe slightly longer; stamens 4, 2 shorter and 2 longer; ovary superior, densely pubescent, 2-celled, style up to 1.5(–2) cm long, stigma with 2 short lobes. Fruit a club-shaped capsule 2–3 cm long, pubescent and glandular, usually 4-seeded. Seeds ovoid, flattened, 4–5 mm long, grey to brown, with crenate margins, tuberculate, supported by retinacula.



Asystasia gangetica – 1, flowering and fruiting branch; 2, flower in longitudinal section; 3, dehisced fruit.
Source: PROSEA

Other botanical information *Asystasia* comprises about 50 species, and is distributed in the tropics of the Old World, with about 30 species in tropical Africa. Two subspecies can be distinguished within *Asystasia gangetica*. Subsp. *micrantha* (Nees) Ensermu, with corolla normally less than 2.5 cm long and style less than 1.5 cm long, is diploid ($2n$ = 26) and distributed in tropical Africa, the Indian Ocean islands and Arabia. Subsp. *gangetica*, with corolla normally more than 2.5 cm long and style more than 1.5 cm long, is tetraploid ($2n$ = 52) and distributed in India, Sri Lanka, South-East Asia and islands of the Pacific Ocean, and introduced in tropical America. Both subspecies can be weedy, but subsp. *micrantha* is more serious as it is more vigorous and tends to become decumbent, producing a dense carpet of rooting stems and foliage.

Growth and development The period from seedling emergence to seed dispersal can be as short as 8 weeks in open areas, but it can take 2 weeks longer in partially shaded areas. It takes one month from flower development to seed dispersal. The seeds are thrown as far as 6 m by an explosive opening mechanism of the fruits, triggered by hot afternoons.

Asystasia gangetica is a shade-loving plant and optimum photosynthesis occurs between 30% and 50% full sunlight. With no weeding, its proportion in the undergrowth of a young oil palm plantation increased in a period of 2 years from 25% to 84%. It grows, though slowly, under a closed canopy of oil palm with less than 10% full sunlight.

Ecology *Asystasia gangetica* is found along roadsides and river banks, in more or less water-logged areas as well as well-drained cultivated areas, from sea-level up to 2500 m altitude. In areas with a dry season of 4 months or more it may not survive. It thrives on coastal alluvium, peat soils with 85% organic matter and pH 3.5–4.5, sandy loams and clay soils.

Propagation and planting *Asystasia gangetica* can be propagated by seed and stem cuttings with 1–3 nodes. Single-node cuttings buried in soil produce flowers and fruits within 6 weeks.

Management Its agressiveness, high uptake of soil nutrients and ability to smother other species have characterized *Asystasia gangetica* as a weed in plantation management. However, the high palatability and digestibility of *Asystasia gangetica* make it attractive to grazing animals as plantation undergrowth.

Diseases and pests *Asystasia gangetica* is susceptible to the fungus *Colletotrichum dematium*, which causes necrosis, defoliation and stunted growth. In West Africa it was observed as a host plant for a mottle virus, transmitted by aphids.

Harvesting Young tender leaves and shoots of *Asystasia gangetica* are collected as a vegetable. Frequent cutting for stall feeding induces early dieback because the stems have long internodes and growing points higher up the stems. Low grazing pressures or long intervals between grazing allow the plant to flower and set seed. It is usually consumed fresh by animals but it can be conserved as hay if properly dried.

Yield For *Asystasia gangetica* grown under heavy shade (6–16% full sunlight) dry matter yields of 2–5 t/ha have been recorded, but under a more open canopy of *Leucaena leucocephala* (Lamk) de Wit at 2 m × 1 m spacing, yields of 3.5–8 t/ha were obtained. Cattle production in the range of 110–135 kg/ha per year, equivalent to 270–310 g/head per day, can be achieved from native forages mixed with *Asystasia gangetica* grown under oil palm.

Handling after harvest *Asystasia gangetica* leaves can be dried, pounded, and the powder

stored for use in the dry season.

Genetic resources There are no known germplasm collections of *Asystasia gangetica* and no breeding programmes. It is not at risk of genetic erosion. More attention to its different types may be desirable, focusing on vegetable use, forage use, medicinal properties, weedy characteristics and ornamental value.

Prospects *Asystasia gangetica* may have potential and warrants research as a nutritious vegetable, as an auxiliary plant in agriculture and as a forage plant. It may be used as a substitute for legumes in the production of leaf meal. However, the spreading of some types as a serious weed needs attention.

Major references Adetula, O.A., 1987; Ensermu Kelbessa, 1994; Kang, L.C., 1981; Katende, A.B., Ssegawa, P. & Birnie, A., 1999; Lee, S.A. & Chen, C.P., 1992; Leung, W.-T.W., Butrum, R.R. & Chang, F.H., 1972; Maundu, P.M., Ngugi, G.W. & Kabuye, C.H.S., 1999; Sri Endreswari, 2003; Ugborogho, R.E. & Adetula, O.A., 1988; van der Zon, A.P.M. & Grubben, G.J.H., 1976.

Other references Adetula, O.A., 1985; Akah, P.A. et al., 2003; Bosser, J. & Heine, H., 2000a; Kiew, R. & Vollesen, K., 1997; Rajaratnam, J.S., Chan, K.W. & Ong, H.T., 1976; Tan, T.K. & Tow, S.A., 1994; Yeoh, H.H. & Wong, P.F.M., 1993.

Sources of illustration Lee, S.A. & Chen, C.P., 1992.

Authors O.A. Adetula

ASYSTASIA MYSORENSIS (Roth) T.Anderson

Protologue Journ. Linn. Soc., Bot. 9: 524 (1867).

Family Acanthaceae

Synonyms *Asystasia schimperi* T.Anderson (1864), *Asystasia rostrata* (Hochst. ex Nees) Solms (1867).

Origin and geographic distribution *Asystasia mysorensis* occurs in central, eastern and southern Africa, from Ethiopia and Eritrea to Namibia and South Africa.

Uses The leaves and young shoots of *Asystasia mysorensis*, usually collected from the wild at the beginning of the rainy season, are eaten as a vegetable in Tanzania; they are sometimes available on local markets. They are eaten boiled, alone or mixed with e.g. cowpeas, tomatoes, onions, coconut milk, pounded oyster nuts (*Telfairia pedata* (Sm. ex Sims) Hook.) or groundnuts, and served with a staple food. *Asystasia mysorensis* is also useful as a fodder and potentially as an ornamental.

Botany Erect or scrambling annual herb up to 45 cm tall, shortly hairy. Leaves opposite, simple, petiolate; blade ovate to obovate, up to 6 cm × 2 cm, entire. Inflorescence a terminal spike up to 5 cm long; bracts enclosing the flowers, green, longer and wider than sepals. Flowers bisexual; sepals 5, linear; corolla tubular, c. 1.5 cm long, white with green spotted throat, 2-lobed, upper lobe again 2-lobed, lower one 3-lobed; stamens 4, anthers minutely mucronate at the base; ovary superior, 2-celled, hairy, style slender, stigmas 2. Fruit a stalked capsule c. 2 cm long, pubescent and bearing small glands, at maturity opening with 2 valves, 1–4-seeded. Seeds angular, supported by retinacula.

Asystasia comprises about 50 species, distributed in the Old World tropics, mostly in Africa. *Asystasia mysorensis* is related to the better known *Asystasia gangetica* (L.) T.Anderson, of which the leaves are also used as a vegetable and fodder, and which has numerous medicinal properties. *Asystasia buettneri* Lindau (synonyms: *Asystasia calycina* Benth., *Asystasia dryadum* S.Moore), distributed in West Africa from Guinea to Gabon, is used similarly as a vegetable in Gabon. A decoction of its leaves is used medicinally against headache and yaws and a poultice is applied against craw-craw sores (ulcers).

Ecology *Asystasia mysorensis* occurs at forest edges, in thickets and secondary regrowth, and as a weed in fields. It is found in many soil types at altitudes up to 2200 m, in Tanzania in areas with an annual rainfall of 1000–2100 mm.

Genetic resources and breeding *Asystasia mysorensis* is common in its area of distribution and not in danger of genetic erosion.

Prospects *Asystasia mysorensis* will remain a minor vegetable of local importance.

Major references Agnew, A.D.Q. & Agnew, S., 1994; Ruffo, C.K., Birnie, A. & Tengnäs, B., 2002.

Other references Meyer, P.G., 1968; Sri Endreswari, 2003.

Authors P.C.M. Jansen

BARLERIA OPACA (Vahl) Nees

Protologue A.DC., Prodr. 11: 230 (1847).
Family Acanthaceae
Synonyms *Justicia opaca* Vahl (1805).
Vernacular names Child's vegetable (En).
Origin and geographic distribution *Barleria opaca* occurs in western and central tropical Africa, from Côte d'Ivoire to Gabon.

Uses The leaves of *Barleria opaca*, collected from the wild, are eaten as a cooked vegetable, e.g. in Ghana and Gabon. The leaves are also used to treat children for piles by squatting in a warm decoction. In Nigeria the whole plant is used in treating jaundice, rheumatism and paralysis, and the leaf sap is applied against catarrh.

Properties The composition of fresh leaves of *Barleria opaca* is per 100 g: moisture 81 g, energy 230 kJ (55 kcal), protein 3.6 g, fat 0.5 g, carbohydrate 11.7 g, fibre 2.7 g, Ca 874 mg , Mg 104 mg, P 38 mg and Zn 0.6 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968).

Botany Scrambling shrub with hairy stems, sometimes rooting at the nodes. Leaves opposite, simple; petiole up to 0.5 cm long; blade elliptical, c. 7.5 cm × 3.5 cm, tapering at both ends, margin entire, with scattered simple hairs at both surfaces. Inflorescence cymose, 1–3-flowered, close together in the upper leaf axils, at apex of branches ending in a dense spike-like structure. Flowers bisexual, zygomorphic, up to 4 cm long; calyx 4-lobed, 2 outer lobes lanceolate, 13–17 mm long, 2 inner ones smaller, shortly bifid at apex; corolla bell-shaped, 2-labiate, white to very pale blue; stamens 2, anthers blue, staminodes 3; ovary superior, 2-celled, glabrous, style terete, glabrous, stigmas 2-lobed. Fruit a spindle-shaped, compressed capsule c. 1 cm long, 2-seeded. Seeds discoid, densely covered by brownish hygroscopic hairs.
Barleria comprises about 300 species and occurs in the Old World tropics except one species, which is found in Central America. The eastern and southern parts of Africa are richest in species. *Barleria opaca* belongs to section *Fissimura*. The leaves of the closely related *Barleria brownii* S.Moore are used similarly as a vegetable, e.g. in Gabon.

Ecology *Barleria opaca* occurs usually in the forest undergrowth in the lowland.

Genetic resources and breeding *Barleria opaca* is rather widespread and there are no indications that it is in danger of genetic erosion.

Prospects *Barleria opaca* will remain a vegetable of minor importance. Its nutritional and medicinal properties need more investigation.

Major references Burkill, H.M., 1985; Busson, F., 1965; Irvine, F.R., 1961; Sillans, R., 1953.

Other references Aguilar, N.O., 2001a; Balkwill, M.J. & Balkwill, K., 1996; Balkwill, M.J. & Balkwill, K., 1997; Leung, W.-T.W., Busson, F. & Jardin, C., 1968.

Authors P.C.M. Jansen

BASELLA ALBA L.

Protologue Sp. pl. 1: 272 (1753).
Family Basellaceae
Chromosome number $2n = 44, 48$
Synonyms *Basella rubra* L. (1753), *Basella lucida* L. (1759), *Basella cordifolia* Lam. (1783).

Vernacular names Ceylon spinach, vine spinach, Gambian spinach, Malabar nightshade, Indian spinach (En). Baselle, brède de Malabar, épinard indien, brède d'Angola (Fr). Bacela, bertalha (Po). Mboga buterezi (Sw).

Origin and geographic distribution Ceylon spinach is usually considered a native of southern Asia, but its exact origin is not known. It is now widely cultivated and naturalized in the tropics and is even grown in temperate zones as an annual. In tropical Africa, it is most common in warm, humid regions and becomes rare towards the drier or colder parts of the continent. It has been recorded in many countries, but probably occurs throughout tropical Africa.

Basella alba – planted and naturalized

Uses Ceylon spinach is commonly grown for its young shoots, which make a succulent, slightly mucilaginous vegetable. It is boiled, used as a potherb in stews or soups, fried in oil, or sometimes used as a green salad. Ceylon spinach is popular among Europeans in Africa as a substitute for spinach, and young tops and seedlings are used as a substitute for corn salad (*Valerianella locusta* (L.) Laterr.). Its fruits have been used for dyeing; the red fruit juice can be used as ink, as cosmetic and for colouring foods. A number of medicinal applications have been reported: young leaves are used as a laxative, and the red fruit juice as eye-drops to treat conjunctivitis. In Kenya the leaves are used to cure stomachache and constipation after childbirth, pulped leaves are applied as a poultice to sores. In East Africa the plant is given to livestock to increase milk production. Red forms of *Basella alba* are commonly planted as ornamentals, and are even popular in Europe and North America as potplants.

Production and international trade Ceylon spinach is sold in many local markets. It is a minor vegetable and since it is generally grouped together with other greens, no data on production or trade are available.

Properties The composition of fresh Ceylon spinach shoots per 100 g edible portion is: water 93 g, energy 79 kJ (19 kcal), protein 1.8 g, fat 0.3 g, carbohydrate 3.4 g, Ca 109 mg, P 52 mg, Fe 1.2 mg, vitamin A 8000 IU, thiamin 0.05 mg, riboflavin 0.16 mg, niacin 0.50 mg, folate 140 μg, ascorbic acid 102 mg (USDA, 2002). The composition is comparable to other dark green leafy vegetables with a high moisture content.

The leaves contain several triterpene oligoglycosides of the oleanane-type, including basellasaponins, betavulgaroside I, spinacoside C and momordins. Two antifungal peptides and two ribosome-inactivating proteins with antiviral activity have been isolated from the seeds.

Description Short-lived perennial herb up to 4(–8) m long, succulent; stem twining, slender, smooth, green or purplish. Leaves alternate, simple, fleshy; stipules absent; petiole up to 9 cm long; blade ovate to heart-shaped, 2.5–15 cm × 2–12.5 cm, usually cordate at base, acute or acuminate at apex, dark green or purplish. Inflorescence an axillary spike up to 22(–30) cm long, hanging, with long peduncle. Flowers bisexual, regular, 5-merous, sessile, 2.5–6 mm long, white, pink or purple; perianth fleshy, urceolate, remaining closed; stamens inserted near apex of perianth tube; ovary superior, 1-celled, ovoid, style with 3 linear stigmas. Fruit a subglobose pseudo-berry 4–7(–10) mm in diameter, enveloped by the fleshy perianth, purplish black, containing a violet juice, 1-seeded. Seed globose, c. 3 mm in diameter, dark brown to black. Seedling with epigeal germination; cotyledons large; first leaves opposite, later ones alternate.

Basella alba – flowering and fruiting shoot.
Source: PROSEA

Other botanical information *Basella* comprises 5 species, 3 of which are endemic to Madagascar and 1 to eastern Africa. *Basella alba* can be confused with *Anredera cordifolia* (Ten.) Steenis, which is sometimes cultivated as an ornamental in tropical Africa. The latter can be distinguished by its slender racemes of pedicellate, non-fleshy flowers.

Growth and development After germination of the seed, growth of the creeping or climbing stem is fast and lateral branches are soon formed. Ceylon spinach sends out runners over the soil which develop new roots at the nodes, thus growing on indefinitely. Harvesting the young tips stimulates branching. Leaves on lateral branches are smaller than those on runners, and with plant senescence leaf size decreases. Flowering starts about 6 weeks after

sowing. The flowers are self-pollinated. The fruits ripen in about 1 month. *Basella alba* is often cultivated as an annual, but with adequate care it persists for over one year in cultivation.

Ecology Ceylon spinach does well in tropical lowlands at elevations up to 500 m, but it survives even at 2600 m altitude and in temperate regions. Under natural conditions, it can be found in forest margins and clearings, and in thickets, often in slightly wet localities. Ceylon spinach does not tolerate frost. The optimal temperature range is 20–35°C. It is a short-day plant; flowering is inhibited at daylengths longer than 13 hours. It responds to light shading by producing larger and more succulent leaves than when fully exposed. It is one of the tropical species that has a C_4 photosynthetic pathway, resulting in fast photosynthesis and high dry matter production under high light intensity, high temperature and adequate moisture and soil fertility. Ceylon spinach tolerates high rainfall and survives short periods of drought. Water stress encourages early flowering. It grows well in a variety of soils, but prefers humus-rich well-drained soils with pH 5.5–7.0. It does not like stagnant water. It will produce some foliage even on poor shallow soils, but is intolerant of salinity.

Propagation and planting Ceylon spinach is grown as a short-term crop of 2–4 months without support or as a long-term crop grown on trellises. Propagation is by seed or, occasionally, by cuttings of about 20 cm long. For short-term crops direct sowing is practised, as well as transplanting of seedlings or cuttings. Seedlings 10–15 cm tall or rooted cuttings are transplanted to beds at a square spacing of 40–50 cm × 40–50 cm or in rows 60–70 cm apart and 25–30 cm between plants. Plants grown from seed are more productive than those grown from cuttings. The 1000-seed weight is 30–40 g. For a short-term crop, Ceylon spinach may be direct sown at a rate of 300 seeds per m^2 (10 g/m^2) in rows 10 cm apart. Thinning is done to 100 plants per m^2 after 15 days at the cotyledon stage. For a long-term crop, 3–4 seeds per hole are sown directly into beds, in double lines on either side of supports 1.2–1.5 m high, with 60 cm between the rows and 30 cm in the row. When grown on a commercial scale, a density of 5 plants per m^2 is often practised.

Management Watering should be liberal until plants are well established; subsequently irrigation of about 8 mm daily is required during dry periods. Partial shading is recommended because it results in the production of larger and more succulent leaves. Trellising has the advantage that the foliage is kept off the ground. This facilitates harvesting and keeps the leaves clean. Ceylon spinach can do well under conditions of moderate fertility, but is responsive to supplemental NPK and organic fertilizer. An appropriate rate of fertilization is up to 100 t/ha organic manure supplemented with 250 kg/ha NPK 10–10–20 before planting, followed by 250 kg/ha NPK after 1 month. Straw mulching is beneficial especially in the early stages of development and during dry periods to conserve water.
For seed production, plants are grown on trellises during the dry season with irrigation. Fruits are picked when dry: a seed yield of 1000–2000 kg/ha can be obtained.

Diseases and pests Ceylon spinach is very susceptible to root-knot nematodes (*Meloidogyne* spp.). The damage is reduced by the application of a high dose of organic manure. Crop rotation with non-susceptible crops such as maize or amaranth is recommended. Ceylon spinach is remarkably free of foliar diseases and pests due to the thick leaf cuticle. Necrotic leaf spots caused by *Cercospora basellae* and *Acrothecium basellae* sometimes occur. Young plants are susceptible to *Rhizoctonia* rot. A rust (possibly *Puccinia* species) causing yellow-orange spots on the leaves is reported as problematic in Congo. Removal of all infected leaves is recommended in order to reduce the inoculum rate.

Harvesting The harvest of a short-term crop begins about 3 weeks after sowing. Tips of branches 15–25 cm long are pinched out weekly for a period of about 2 months. For a long-term crop, the harvest starts 5–6 weeks after sowing, or somewhat earlier if cuttings were used. For transplanted seedlings, harvesting starts 50–70 days after transplanting. Harvesting continues at regular intervals for up to 6 months, when the leaves become too small.

Yield A short-term crop yields up to 40 t/ha in 75 days; for long-term crops, yields are very variable, up to 1.5 kg of shoots or leaves per plant or 80 t/ha in 180 days. Yields of 20–50 t/ha per month of cultivation have been reported.

Handling after harvest To reduce deterioration the shoots are tied in bunches. Ceylon spinach keeps only one day at temperatures of 20–30°C. For longer storage, the product

should be kept in a cool room. The leaves are not usually dried.

Genetic resources *Basella alba* is not endangered because local selections are commonly grown in home gardens and for the market. It has been included in the traditional African Vegetables Mandate list for conservation in the SADCC region. No germplasm collection by national genebanks is reported. Germplasm is being conserved *in situ* in the custody of the farmers. Collection and screening of local material is advisable.

Breeding No breeding programmes are known to exist, although several seed companies in India and the United States offer their own selections.

Prospects Ceylon spinach has good prospects as a productive leafy vegetable with excellent nutritional properties, a remarkable resistance to diseases and pests, suitable for backyard cultivation as well as for market gardens in the lowland tropics.

Major references FAO, 1988; Grubben, G.J.H., 1977; Guarino, L., 1997; Messiaen, C.-M., 1989; Rahmansyah, M., 1993a; Sidwell, K., 1999; Tindall, H.D., 1983; USDA, 2002a.

Other references Makambila, C., 1986; Maundu, P.M., Ngugi, G.W. & Kabuye, C.H.S., 1999; Murakami, T., Hirano, K. & Yoshikawa, M., 2001; Olembo, N.K., Fedha, S.S. & Ngaira, E.S., 1995; van der Zon, A.P.M. & Grubben, G.J.H., 1976; Wang, H. & Ng, T.B., 2001.

Sources of illustration Rahmansyah, M., 1993a.

Authors M.O. Abukutsa-Onyango
Based on PROSEA 8: Vegetables.

BEGONIA MACROCARPA Warb.

Protologue Engl., Bot. Jahrb. 22(1): 43 (1895).

Family Begoniaceae

Synonyms *Begonia auriculata* auct. non Hook.f.

Vernacular names Oseille de la brousse, oseille de gorille, oseille de chimpanzé (Fr).

Origin and geographic distribution *Begonia macrocarpa* is widespread from Guinea to DR Congo and Angola.

Uses In Gabon *Begonia macrocarpa* leaves are eaten as a cooked vegetable, as a substitute for sorrel (*Rumex* spp.). They are appreciated for their acidulous taste and combine well with fish or crocodile meat in stews.

Botany Erect perennial herb up to 110 cm tall; stem succulent, swollen at the nodes, slightly hairy to glabrous. Leaves alternate, simple; stipules ovate, 2–8(–10) mm long, toothed, caducous; petiole (0.5–)1–4(–5.5) cm long; blade narrowly ovate, slightly asymmetrical, (2–)4–15(–19) cm × (1–)2.5–6(–7) cm, cordate at base, acuminate at apex, margin entire, slightly succulent, glabrous. Inflorescence an axillary scorpioid cyme with up to 17 male flowers and 1 female flower; peduncle 1–1.5(–2.5) cm long. Flowers unisexual, with 2 tepals, white, often reddish at base; male flowers with broadly ovate to circular tepals 0.5–1 cm long and up to 17(–23) stamens fused at base, all anthers facing into one direction; female flowers with ovate or obovate tepals 1–1.5 cm long, ovary inferior, 3-celled and 3-winged, styles 3, up to 6.5 mm long, fused at base. Fruit a 3-winged capsule 1.5–3 cm × 1.5–3 cm, many-seeded.

Begonia comprises about 1400 species, with about 160 in tropical Africa. *Begonia macrocarpa* belongs to section *Filicibegonia* and is closely related to *Begonia auriculata* Hook.f., which usually has larger leaves and stipules and a longer peduncle, and is endemic to Gabon.

In Central Africa several other *Begonia* species are eaten as a vegetable in a similar way to *Begonia macrocarpa*, e.g. *Begonia elatostemmoides* Hook.f., *Begonia eminii* Warb., *Begonia fusialata* Warb., *Begonia hirsutula* Hook.f., *Begonia komoensis* Irmsch., *Begonia sciaphila* Gilg ex Engl., *Begonia scutifolia* Hook.f. and *Begonia sessilifolia* Hook.f.

Ecology *Begonia macrocarpa* occurs in primary and secondary forest, especially along roads and rivers, up to 1000 m altitude.

Genetic resources and breeding *Begonia macrocarpa* is widespread and even occurs in disturbed habitats, and is consequently not liable to genetic erosion.

Prospects *Begonia macrocarpa* and other *Begonia* species will probably remain minor vegetables, which are locally popular because they impart an acidulous flavour to meat and fish.

Major references de Wilde, J.J.F.E., 2002; Raponda-Walker, A. & Sillans, R., 1961; Sosef, M.S.M., 1994.

Other references Arends, J.C., 1992; Burkill, H.M., 1985; Doorenbos, J., Sosef, M.S.M., & de Wilde, J.J.F.E., 1998.

Authors R.H.M.J. Lemmens

BENINCASA HISPIDA (Thunb. ex Murray) Cogn.

Protologue A.DC, Monogr. phan. 3: 513 (1881).

Family Cucurbitaceae

Chromosome number $2n = 24$

Synonyms *Cucurbita hispida* Thunb. ex Murray (1784), *Benincasa cerifera* Savi (1818).

Vernacular names Wax gourd, Chinese winter melon, white gourd, ash gourd, fuzzy melon (En). Courge cireuse, bidao, courgette velue (Fr). Abóbora d'agua, comalenge (Po).

Origin and geographic distribution Wax gourd is a cultigen probably originating from Indo-China. It is not found in the wild and no related species are known. It has been grown since ancient times in southern China, Japan, and southern and south-eastern Asia. Wax gourd is now widely cultivated throughout tropical Asia and is also rather popular in the Caribbean and the United States. In Africa it is a vegetable crop of limited importance, grown mainly in East and southern Africa. In Madagascar and Mauritius it was formerly cultivated, but it seems to have vanished at present.

Uses Wax gourd is grown both for its immature and mature fruits. The immature fruits, called fuzzy melons, have a delicate taste and flavour and are prepared in the same way as summer squash from *Cucurbita pepo* L. In India they are used extensively in curries. The ripe fruits have juicy greenish-white flesh with a flat taste. They are especially popular among people of Asian descent, but they are also liked by many Africans. The skin is peeled or scraped off, seeds and pith are removed, and the flesh is cooked in soups. In China the fruits are often stuffed with meat, shrimps and vegetables and then steamed in a pot. The firm flesh of the older fruits is also candied with sugar and can be dried for later use. Young shoots, leaves and flowers are occasionally eaten too. The seeds are prepared as a snack food by frying. In India, the wax of the fruits was formerly scraped off to make candles. Wax gourd is sometimes used as a rootstock for melon (*Cucumis melo* L.). The fruits are valued for their medicinal properties. In India and China they are used as an anthelmintic, antiperiodic, aphrodisiac, for lowering blood sugar, against epilepsy, insanity and other nervous diseases, haemophysis and haemorrhage, and as a diuretic, laxative and bitter tonic. They are recommended in Ayurvedic medicine for the management of peptic ulcers. The seeds are used as a vermifuge.

Benincasa hispida – planted

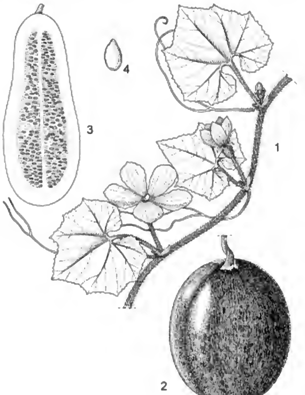
Production and international trade Wax gourd is a rather important market vegetable in subtropical and tropical Asia, and the immature fruits are increasingly popular in city markets. In Africa wax gourd is grown occasionally for local and city markets; in peri-urban gardens more for the young fruits, in rural areas more for the mature ones. There are no known statistical data.

Properties The edible portion of wax gourd is about 70% of the total fruit weight. The nutritional composition of mature wax gourd fruits per 100 g edible portion is: water 96.1 g, energy 54 kJ (13 kcal), protein 0.4 g, fat 0.2 g, carbohydrate 3.0 g, dietary fibre 2.9 g, Ca 19 mg, Mg 10 mg, P 19 mg, Fe 0.4 mg, Zn 0.6 mg, carotene absent, thiamin 0.04 mg, riboflavin 0.11 mg, niacin 0.40 mg, folate 5 μg, ascorbic acid 13 mg (USDA, 2002). The content of micro-nutrients in young fruits is probably somewhat higher, notably of ascorbic acid.
Fruit extracts of wax gourd showed anti-ulcer activity in tests with mice and rats. Fruit juice also showed significant activity against symptoms of morphine withdrawal in tests with mice. Histamine-release inhibitors were isolated from wax gourd fruits; the triterpenes alnusenol and multiflorenol were the most active inhibitors. An immuno-potentiator has been isolated from the seeds, markedly stimulating the proliferation and differentiation of murine B cells. Wax gourd fruits contain cucurbitacin B, which is known to exhibit cytotoxic and anti-inflammatory activities.

Adulterations and substitutes In dishes, wax gourd can be replaced by young fruits of

bottle gourd (*Lagenaria siceraria* (Molina) Standl.).

Description Usually monoecious, annual herb climbing by 2–3-fid tendrils up to 35 cm long; stem up to 5 m long, thick, terete, longitudinally furrowed, whitish-green with scattered rough hairs. Leaves distichously alternate, simple; stipules absent; petiole 5–20 cm long; blade broadly ovate in outline, 10–25 cm × 10–20 cm, deeply cordate at base, apex acuminate, margin more or less deeply and irregularly 5–11-angular or -lobed and irregularly undulate-crenate or toothed, densely patently hispid on both sides, 5–7-veined from the base. Flowers solitary in leaf axils, unisexual, regular, 5-merous, 6–12 cm in diameter; calyx campanulate, densely silky; petals almost free, yellow; male flowers with pedicel 5–15 cm long and 3 stamens; female flowers with pedicel 2–4 cm long, an inferior, ovoid or cylindrical, densely villose ovary, and a short style with 3 curved stigmas. Fruit an ovoid-oblong, ellipsoid or globose berry 20–60(–200) cm × 10–25 cm, dark green to speckled pale green or glaucous, hispid when immature, thinly hispid or subglabrous when ripe, covered with a chalk-white, easily removable wax layer; flesh greenish white, juicy, slightly fragrant, spongy in the middle, containing many seeds. Seeds ovate-elliptical, flattened, 1–1.5 cm long, yellow-brown, sometimes prominently ridged.



Benincasa hispida – 1, part of flowering stem; 2, fruit; 3, fruit in longitudinal section; 4, seed. Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Benincasa* comprises a single species. Numerous types are distinguished, mainly differing from each other in fruit size and shape, colour, hairiness and amount of wax present. A classification into 16 cultivar-groups has been proposed, but the main distinction in improved cultivars is between types suitable for harvest of the young fruits, the 'fuzzy melon' type, and cultivars grown for the mature gourds, the true 'wax gourd' type. From some landraces in India both the young and mature fruits are used.

Growth and development Wax gourd is a vigorous grower, but it needs a long growing season of 4–5 months. Flowering starts about 45 days after sowing for early types and up to over 100 days after sowing for late ones. The flowers are insect-pollinated. Sex ratio is 1 female flower to 20–33 male ones in primitive types, but modern selections and hybrids are predominantly female. The ratio of female to male flowers increases with lower temperatures and with shorter days. Young fruits are harvestable 8 days after anthesis or later, depending on the size wanted by the market. The fruits need 1–2 months from anthesis until full maturity, 50–72 days in modern improved cultivars. A regular harvest of young fruits prolongs the flowering period and the crop duration. Fruits contain 15–45 g of seed.

Ecology Wax gourd is best suited for moderately dry areas in the tropics. It is relatively drought tolerant. It grows well at temperatures above 25°C, the optimum temperature for growth ranging from 23–28°C (24 h average). It is suited to tropical lowland conditions and elevations up to 1000 m altitude. It prefers a well-drained light soil with pH 6.0–7.0.

Propagation and planting Both direct-seeding and sowing in pots and transplanting is practised if grown for immature fruits, whereas for the production of mature wax gourd fruits only direct sowing is practised. Direct sowing is done in trenches or planting holes filled with manure or compost. When grown trellised for young fruits, plants are spaced at 50–70 cm in the row, with the rows 1.5–2.0 m apart or about 10,000 plants/ha, when grown for mature fruits and stems allowed to trail there are about 5000 plants/ha. In intensive growing systems for immature

fruits, the seed requirement is 400–500 g/ha if transplanting is practised and 800–1000 g/ha for direct sowing. One gram contains 12–25 seeds. Farmers who produce farm-saved seed usually use up to 2 kg/ha. For wax gourd in India farmers use a seed rate of about 5 kg/ha.

Management Wax gourd grown for mature fruits is planted on flat land, whereas the fuzzy melon type is mostly grown upright, e.g. against trellises. It needs a fertile soil and responds well to much organic matter, e.g. 30 t manure per ha. An application of NPK fertilizer is recommended before sowing and a nitrogenous fertilizer as a side-dressing at regular intervals until flowering. Ample irrigation is needed during dry periods. In the rainy season, fruits of trailing plants can be protected from rotting by putting them on some straw. Pruning of stem tips and flowers is sometimes carried out to achieve better growth of fruits.

Diseases and pests Wax gourd is moderately susceptible to anthracnose (*Colletotrichum lagenarium*) and gummy stem blight (*Didymella bryoniae*), for which no tolerance has been identified yet. It is also moderately susceptible to fruit rot (*Fusarium solani*) and cavity rot (*Verticillium dahliae*) but rather resistant to leaf fungi that are devastating on other cucurbits such as downy mildew (*Pseudoperonospora cubensis*) and powdery mildew (*Erysiphe cichoracearum* and *Sphaerotheca fuliginea*). Wax gourd is susceptible to watermelon mosaic virus (WMV) transmitted by aphids. Among the insect pests are squash beetle (*Aulacophora foveicollis*), aphids (*Aphis gossypii*) and fruit flies (*Dacus* spp.). These pests and diseases are seldom serious enough to justify chemical sprays.
Western seed companies have selected special wax gourd cultivars as disease resistant rootstock for other cucurbits (cucumber, water melon, melon) because of growth vigour and resistance to Fusarium wilt and root-knot nematodes. Wax gourd combines best with melon, but in practice growers prefer rootstocks from *Cucurbita* species (hybrids of *Cucurbita moschata* Duchesne and *Cucurbita maxima* Duchesne) and bottle gourd (*Lagenaria siceraria*), because wax gourd is susceptible to *Phomopsis sclerotioides*, a root disease of melon and cucumber in protected cultivation.

Harvesting Immature fruits are harvested at weekly intervals when they weigh 300–1000 g. Mature fruits are harvested from 100–160 days after sowing; depending on the cultivar, the harvestable fruit weight varies from 3–40 kg, but is commonly around 10 kg.

Yield Yields of young fruits of more than 30 t/ha, harvested 60–100 days after sowing, have been reported. Mature wax gourd in India yields about 20 t/ha. A seed yield of 100–150 kg/ha is recorded from India; 200–300 kg/ha from Thailand.

Handling after harvest Young fruits are rather perishable. Mature fruits can be stored for over a year if kept at 13–15°C and 75% relative humidity due to the waxy layer that protects them from attack by micro-organisms.

Genetic resources With the increased popularity of improved cultivars in Asian countries, local cultivars are disappearing in Asia. No germplasm collections are known from Africa, but germplasm collections are available at horticultural institutes in other tropical regions, mainly in the Philippines (Institute of Plant Breeding), India (Kerala Agricultural University), Russia (N.I. Vavilov Institute of Plant Industry, Petersburg) and the United States (Southern Regional Plant Introduction Station, Georgia; Cornell University, New York).

Breeding Several seed companies in India, Thailand, Taiwan, China and Japan have carried out selection work on local cultivars. Selection criteria are fruit quality, few seeds, high yield, earliness and resistance to diseases. Wax gourd of both types is offered in seed catalogues. Seed companies in India, Thailand, Taiwan, China, Japan and the United States offer improved cultivars of fuzzy melons. Several seed companies including East West Seed Company have developed vigorous F_1 cultivars of fuzzy melon with superior yield and fruit quality. Examples are 'Pearl F_1', a pale green midlate cultivar, harvestable 75 days after sowing, and 'Jade F_1', an early cultivar, harvestable 55 days from sowing. Wax gourd cultivars were developed at Coimbatore in South India, e.g. 'Co-2', a selection with small fruits (3 kg) harvestable 120 days after sowing.

Prospects Although at present of little importance in tropical Africa, wax gourd merits attention as an easy-to-grow vegetable suitable for home gardens and market production, with immature fruits having a good taste and mature fruits having excellent keeping quality.

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Authors G.J.H. Grubben

BETA VULGARIS L.

Protologue Sp. pl. 1: 222 (1753).

Family Chenopodiaceae (APG: Amaranthaceae)

Chromosome number $2n = 18$

Vernacular names Garden beet, beetroot, spinach beet, leaf beet, Swiss chard (En). Betterave potagère, betterave rouge, bette-épinard, poirée à couper, poirée à carde, bette à carde, côte de blette (Fr). Betteraba de mesa, betteraba vermelha, acelga (Po).

Origin and geographic distribution Wild forms of *Beta vulgaris* occur along the shores of the Mediterranean, extending eastwards as far as Indonesia, and westwards along the coasts of the Atlantic up to the Canary Islands and southern Norway. *Beta vulgaris* grown for its leaves was taken into cultivation in the eastern Mediterranean or the Middle East and is first mentioned in the literature in Mesopotamia in the 9th century BC. Recipes for roots of beet date from the 3rd century AD, but true garden beets appear in Europe as late as the 16th century. Little is known of the development and early distribution of Swiss chard. Presently, beets are grown for their roots (garden beet), petioles (Swiss chard) and leaves (spinach beet) throughout the world. Garden beet is the most important form worldwide and can be found in all African countries, more in the cooler parts of East and southern Africa than in the lowlands, and mostly as a relatively minor market vegetable around the big cities. In most African countries spinach beet/Swiss chard is far more important than garden beet, which is primarily consumed by Europeans. Two other cultivated forms of *Beta vulgaris*, fodder beet and sugar beet are of no importance in tropical Africa.

Beta vulgaris – planted

Uses Spinach beet leaves are eaten as pot herb. Young leaves of the garden beet are sometimes used similarly. The midribs of Swiss chard are eaten boiled while the whole leaf blades are eaten as spinach beet; in Africa the whole leaf blades are usually prepared with the midribs as one dish. The usually deep-red roots of garden beet are eaten boiled either as a cooked vegetable, or cold as a salad after cooking and adding oil and vinegar. A large proportion of the commercial production is processed into boiled and sterilized beets or into pickles. In eastern Europe beet soup is a popular dish. Yellow-coloured garden beets are grown on a very small scale for home consumption. In Africa the leaves are preferred to the roots.
Roots and leaves are used medicinally against infections and tumours, and Swiss chard as a hypoglycaemic agent by diabetic patients. Garden beet juice is a popular health food, although it is not important in tropical Africa. Betanins, obtained from the roots, are used industrially as red food colourants, e.g. to improve the colour of tomato paste, sauces, desserts, jams and jellies, ice cream, sweets and breakfast cereals.
Forms with strikingly coloured, large leaves are grown as ornamentals.

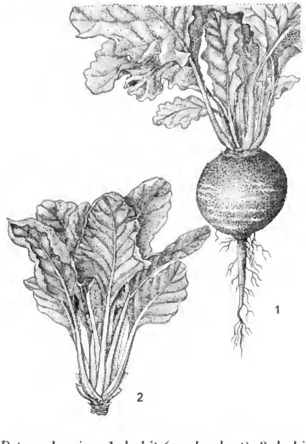
Production and international trade Europe and North America produce the bulk of the garden beet crop and their combined annual commercial production amounts to 900,000 t (excluding Eastern Europe). Spinach beet is important in northern India and parts of South and Central America, as well as in Italy. In tropical Africa, beet crops are grown on a limited scale for home consumption and for local markets, but no production data are available.

Properties Raw garden beet contains per 100 g edible portion: water 87.6 g, energy 180 kJ (43 kcal), protein 1.6 g, fat 0.2 g, carbohydrate 9.6 g, fibre 2.8 g, Ca 16 mg, P 40 mg, Fe 0.8 mg, thiamin 0.03 mg, riboflavin 0.04 mg,

niacin 0.33 mg, folate 109 µg, ascorbic acid 5 mg. The carbohydrate consists almost purely of saccharose. The composition of raw spinach beet per 100 g edible portion is: water 92.0 g, energy 79 kJ (19 kcal), protein 1.8 g, fat 0.1 g, carbohydrate 4.0 g, fibre 3.7 g, Ca 119 mg, P 40 mg, Fe 3.3 mg, thiamin 0.10 mg, riboflavin 0.22 mg, niacin 0.40 mg, folate 15 µg, ascorbic acid 30 mg. The composition of raw Swiss chard per 100 g edible portion is: water 92.7 g, energy 79 kJ (19 kcal), protein 1.8 g, fat 0.2 g, carbohydrate 3.7 g, fibre 1.6 g, Ca 51 mg, P 46 mg, Fe 1.8 mg, thiamin 0.04 mg, riboflavin 0.09 mg, niacin 0.40 mg, folate 14 µg, ascorbic acid 30 mg (USDA, 2002).

The colouring agents in garden beet are not anthocyans, but glucopyranosides, mainly beetroot red or betanine ($C_{24}H_{27}N_2O_{13}$ - E162). It is water soluble and sensitive to high temperatures, oxygen and light. Beets also contain geosmin, which causes the typical earthy smell.

Description Robust, erect, usually biennial herb; main root long, stout, tapered, side roots forming a dense, extensive root system in the top 25 cm of the soil; in garden beet, hypocotyl and upper part of the main root conspicuously swollen, being globular, flattened, cylindrical or tapering, adventitious roots occurring in two opposite rows on the lower part, swollen root consisting of alternating layers of mostly strongly coloured conductive tissue and light coloured storage tissue. Leaves in the basal rosette with long petioles, on stems alternate and shortly stalked, often ovate and cordate, 20–40 cm long, margins wavy except in spinach beet, leaf tissue puckered between veins, subglabrous, green, dark green or red, often shiny; in Swiss chard petiole and midrib swollen. Inflorescence a long, paniculate, branched spike up to 150 cm long. Flowers sessile, bisexual, usually 2–3(–5) together, greenish, subtended by minute bracts; perianth 5-partite, becoming thicker at base as fruits ripen; stamens 5; ovary 1-celled, surrounded by a disk, with 2–3 stigmas. Fruit a nut, enclosed within the swollen corky perianth-bases, 3–7 mm in diameter, 1–6 fruits adhering in glomerules. Seed kidney-shaped, brown, 1.5–3 mm in diameter.



Beta vulgaris – 1, habit (garden beet); 2, habit (Swiss chard).
Redrawn and adapted by Iskak Syamsudin

Other botanical information At present it is quite generally accepted that the cultivated taxa of the genus *Beta* all belong to *Beta vulgaris* L. subsp. *vulgaris*. However, there is disagreement concerning the infraspecific classification and the classification of related wild taxa, together constituting section *Beta*. The most recent revision of the wild taxa within section *Beta* distinguishes 3 species: *Beta vulgaris* L. (with subsp. *adanensis* (Pamukç.) Ford-Lloyd & J.T.Williams, and subsp. *maritima* (L.) Arcang.), *Beta macrocarpa* Guss. and *Beta patula* Aiton. There are almost no barriers to gene exchange between the wild and cultivated taxa and a pattern of continuous morphological variation is present.

The classification of both the wild and cultivated forms of *Beta vulgaris* is confusing. Here, the cultivated forms of *Beta vulgaris* are all classified in subsp. *vulgaris*. The classification of the cultivated forms as accepted by the World *Beta* Network and the International Data Base for *Beta* recognizes 4 denomination classes within *Beta vulgaris* subsp. *vulgaris*:

- Garden Beet Group (also named Conditiva Group).
- Leaf Beet Group (in other cultivar-group classifications divided into Swiss chard or Flavescens Group, and Spinach beet or Cicla Group, but many intermediate types exist).
- Fodder Beet Group (also named Crassa Group).
- Sugar Beet Group (also named Altissima Group).

For the vegetable types, some cultivars recom-

mended for the tropics are:

- Garden Beet Group: 'Crimson Globe' and 'Detroit Dark Red';
- Leaf Beet Group (Swiss chard): 'Fordhook Giant', 'Lucullus' and 'Verte à carde blanche de Nice';
- Leaf Beet Group (Spinach beet): 'All Green' and 'Palak'.

Growth and development Beets are biennial plants requiring vernalization for flower induction. In cultivars of temperate areas, 4–10°C for 2 weeks is sufficient to induce flowering. The low-temperature requirements in tropical selections are less. Long daylengths further promote flowering. Flowering in garden beet is also stimulated by high temperatures, which may lead to flowering during the first year in the tropics. This risk does not occur in leaf beet. When grown for seed production, flowering can be obtained by using vernalized seed or seedlings. Pollination is mainly by wind, though flowers produce nectar and are visited by insects, especially thrips. Beets are self-incompatible.

Ecology Temperatures above 25°C adversely affect growth and colour development of garden beet. An elevation of 600–1000 m in the tropics is the minimum for profitable production. Leaf beet tolerates higher temperatures.

Beets require a fertile, moist soil for good growth. They prefer a neutral to slightly alkaline pH. As they originate from seashores, they are tolerant of limited concentrations of salt and can be irrigated with slightly saline water.

Propagation and planting Beets are propagated by seed. The seeds are clustered into glomerules or seedballs. Monogerm seed of modern cultivars is commercially available, obtained through breeding or by mechanical splitting of the seedballs. The 1000-seed weight is 5–10 g, the weight of 1000 seedballs 13–22 g. Seed production in the tropics is difficult and seed is normally imported. Beet root crops are mostly direct-seeded, 2–3 cm deep in rows (12.5–)25–30(–50) cm apart, or broadcast and thinned to 10–20 cm. Some gardeners however may sow beetroot in a nursery and transplant. When whole seedballs are sown, each resulting in 2–5 plants, thinning to single plants is necessary. The plant density depends on the purpose of the crop. For young, high quality minibeets the plant spacing may be as close as 12.5 cm × 5 cm, whereas for a crop of mature garden beets the plant spacing can be 25 cm × 10–13 cm. Spinach beet is sown in rows 15–20 cm apart. Thinning in the row at a rather close distance, 2–10 cm, or no thinning is practised. Swiss chard for early production of the complete plants is sown in rows 20 cm apart and thinned in the row to 5–10 cm. For long-term continuous picking of big leaves it is sown in a nursery and plants of 25 days are transplanted at 30 cm × 30 cm on beds, or at 25 cm × 45 cm so that people can walk between the rows.

Management Relatively large amounts of fertilizer are important for profitable yields. A normal application is 100 kg N, 50 kg P_2O_5 and 200 kg K_2O per ha. Nitrogen can be given as $NaNO_3$ in slightly acidic soils, or where available Na is limited. After picking the first leaves, a top dressing with sulphate of ammonia (for soils with high pH) or calcium ammonium nitrate (for soils with low pH) should be applied; this top dressing to be repeated every 4–6 weeks. Where boron deficiency causes stunted and slow growth, 10–30 kg/ha of borax can be applied. However, too much boron may be toxic to the subsequent crop. For good growth, moist soil is required. Irregular rainfall or inadequate irrigation may cause yellowing of leaves, or leaves that become coarse or bitter, whereas for garden beet it causes cracking of the roots.

Diseases and pests Beets are generally not seriously attacked by diseases or pests, but leaves of spinach beet can be seriously affected by leaf spot caused by the seedborne fungus *Cercospora beticola*, resulting in small round spotting of the leaves, aggravated by high air humidity. For this reason farmers avoid growing this crop in high-rainfall areas unless when they are able to spray with dithane or similar chemicals at intervals of 7–10 days. Other seedborne fungus diseases are downy mildew (*Peronospora parasitica*) on the leaves and *Phoma betae* causing damping-off. *Pythium* and *Rhizoctonia* also cause damping-off.

Larvae of several species of beet web worms feed on leaves and produce webs. Occasionally aphids and beet leafminers are a problem. Beets are very susceptible to *Meloidogyne* root-knot nematodes, controlled by crop rotation and by large applications of organic manure.

Harvesting Garden beets are harvested by uprooting with their leaves and tied into bunches of 3–5. The time from planting to harvesting depends on the size of the roots preferred. Minibeets with a diameter of 3–4 cm can be harvested about 2 months after sowing, full-size beets after 3–4 months.

Leaf beet is usually harvested by cutting the

large outer leaves with a knife. Harvesting of leaf beet can start about 45 days after sowing and can continue for up to 2 years in fertile soil.

Yield With good cultivation techniques garden beet in the tropics may yield 15–25 t/ha. Leaf beet may yield up to 100 kg per bed of 10 m².

Handling after harvest Garden beet can be stored for more than 6 months under cool, well-ventilated conditions, provided the leaves are removed. The optimum temperature is 0–4°C at a relative humidity of 90–95%. Industrially, beets are preserved after steam-boiling and skinning and addition of vinegar, either as whole minibeets or sliced. Leaf beet is a typical fresh market product, but can be kept for some days in a cool store.

Genetic resources The International Beta Database (IDBB) is maintained by the Genebank of the Federal Centre for Breeding Research on Cultivated Plants, Germany. The IDBB serves as the central link within the World Beta Network (WBN). Genetic material collected for breeding work in sugar beet and fodder beet can also be used in breeding vegetable beets. The genus *Beta* has a high priority for IPGRI since diversity is rapidly eroding.

Breeding Breeding work is done in many temperate countries, but also in southern China and northern India. Breeders of garden beet aim for rapid root formation, limited leaf production and petioles narrow at their base, good homogeneous colour, good shape, appearance and taste, and no bolting in the first year.

Prospects Leaf beet with its high productivity and high nutritional value, merits more attention as market vegetables in the cooler parts of the tropics. Cultivars with resistance to high temperatures are needed. Garden beet is mostly grown for the European market. The good transport and storage characteristics are commercially attractive.

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Other references Rubatzky, V.E. & Yamaguchi, M., 1997; Tindall, H.D., 1968.

Sources of illustration Vaughan, J.G. & Geissler, C.A., 1997.

Authors L.P.A. Oyen
Based on PROSEA 8: Vegetables.

BIDENS BIPINNATA L.

Protologue Sp. pl. 2: 831 (1753).
Family Asteraceae (Compositae)
Chromosome number $2n = 24, 36, 48, 72$
Synonyms *Bidens pilosa* L. var. *bipinnata* (L.) Hook.f. (1881).

Vernacular names Spanish needles, hemlock beggar's ticks (En). Bident bipenné, herbe aiguille, herbe à aiguilles (Fr). Carrapicho agulha, beijo de moça (Po).

Origin and geographic distribution *Bidens bipinnata* is a widely distributed weedy species in North and South America, Europe and Asia. It is introduced in Africa and known from Cape Verde, Guinea, Sierra Leone, Côte d'Ivoire, Ghana, Togo, Nigeria, Cameroon, Malawi, Zimbabwe, Madagascar and South Africa.

Uses The young leaves of *Bidens bipinnata* are occasionally eaten as a vegetable. In southern Africa the young shoots are said to have a piquant flavour and are eaten fresh or dried and stored. It is likely that *Bidens bipinnata* is often confused with the more widely spread black jack (*Bidens pilosa* L.) and used instead of the latter and in mixtures. In Sierra Leone the leaves are squeezed over boils and are also eaten to cure them. *Bidens bipinnata* is widely used in South-East Asia as an emmenagogue, expectorant, stimulant, antidiarrhetic and antispasmodic. It is also used in the treatment of conjunctivitis, asthma, insect stings, wounds, earache and snakebites.
Cattle relish the young plant. However, the abundant volatile oil present in the plant has an unpleasant smell and may taint the milk. In Thailand and Brazil *Bidens bipinnata* is grown as an ornamental.

Properties Young leaves of *Bidens bipinnata* have an ascorbic acid content of 40 mg/100 g (Watt, J.M. & Breyer-Brandwijk, M.G., 1962). No other nutritional data are available. The composition of the leaves is likely to be very similar to that of the leaves of *Bidens pilosa* (black jack), for which consumption as a raw vegetable is not recommended because of a high saponin content.
Extracts of *Bidens bipinnata* show antimalarial activity in vivo. The crude ethanol extract (50 μg/ml) causes up to 70% inhibition of *Plasmodium falciparum* growth. Phenylacetylenes and flavonoids have been found in the ethanol extract from the leaves and the roots, and the antimalarial activity may be attributed to the presence of the acetylene compounds. Polyacetylenes also have microbial activity. The flow-

ers and stem have shown antibiotic activity against *Staphylococcus aureus* but not against *Escherichia coli*.

Botany Annual, erect herb up to 1.5(–2.5) m tall, with 4-angled stems, sometimes densely branched. Leaves opposite, rarely alternate towards the upper part of the plant, bipinnatisect with lower segment often 2–3-cleft or pinnatifid, 11–20 cm long; leaflets with short petiolules, ovate to deltoid or the terminal one lanceolate, margins crenate-serrate. Inflorescence a head 4–7 mm in diameter, arranged in lax cymes; outer involucral bracts 7–10, 3–5 mm long, shorter than the inner ones. Ray flowers 3–5, sterile, corolla 5–6 mm long, yellowish white; disk flowers tubular, bisexual, with 4–5 mm long, yellow corolla. Fruit a linear achene 4–13 mm long, 4-ribbed, with 2(–4) retrorsely barbed bristles of 2–4 mm long.
The genus *Bidens* in Africa comprises 63 species. The African species, formerly considered to belong to the genus *Coreopsis*, are now all placed in *Bidens*. *Bidens bipinnata* can be distinguished by its bipinnatisect leaves from the closely related *Bidens pilosa* and *Bidens biternata* L., with 3–5-partite leaves and pinnately 5–9-lobed leaves respectively.
The achenes adhere by means of the bristles to the fur of passing animals or clothes of humans, and are widely dispersed in this way.

Ecology *Bidens bipinnata* is found along roadsides and at margins of fields at 450–1400 m altitude.

Genetic resources and breeding *Bidens bipinnata*, although widespread, is nowhere in Africa very common. As an introduced weedy species, genetic variation is likely to be more important in its native range.

Prospects The use as a vegetable will continue to be locally of some importance. The medicinal, especially the antimalarial, properties deserve research attention.

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Other references Burkill, H.M., 1985; Decary, R., 1946; Serviçio nacional de proteção de cultivares, 1998; van Wyk, B.E. & Gericke, N., 2000.

Authors C.H. Bosch

BIDENS PILOSA L.

Protologue Sp. pl. 2: 832 (1753).

Family Asteraceae (Compositae)

Chromosome number $2n = 24$, 36, 48, 72

Synonyms *Bidens leucantha* (L.) Willd. (1803).

Vernacular names Black jack, cobbler's pegs, hairy beggarticks, Spanish needles (En). Sornet, piquant noir, bident hérissé, herbe aiguille, herbe villebague (Fr). Carrapicho de agulha, picão preto (Po). Kichoma mguu, kichoma nguo (Sw).

Origin and geographic distribution *Bidens pilosa* is a cosmopolitan weed, originating from South America and common in all tropical and subtropical areas of the world. In Africa *Bidens pilosa* is recorded as a weed in many countries and it is likely to occur in all countries, including the Indian Ocean islands. It is reported as a vegetable or potherb among others in Sierra Leone, Liberia, Côte d' Ivoire, Benin, Nigeria, Cameroon, DR Congo, Kenya, Uganda, Tanzania, Malawi, Botswana, Zambia, Zimbabwe and Mozambique.

Uses In sub-Saharan Africa, the fresh or dried tender shoots and young leaves are used as a leaf vegetable especially in times of food scarcity. It is an ingredient of sauces accompanying the staple food. The leaves are, fresh or after parboiling, dried in the sun and stored as powder for the dry season. In Uganda, the leaves are boiled in sour milk. Old leaves are not suitable for consumption because they have a bitter astringent taste.
Bidens pilosa is used as a medicinal plant in many regions of Africa, Asia and tropical America. Roots, leaves and seed have been

Bidens pilosa – *wild*

reported to possess antibacterial, anti-dysenteric, anti-inflammatory, antimicrobial, antimalarial, diuretic, hepato-protective and hypotensive activities. In Uganda, five different medicinal uses are known: the sap from crushed leaves is used to speed up clotting of blood in fresh wounds; a leaf decoction is used for treating headache; sap from the plant is put in the ear to treat ear infection; a decoction of leaf powder is used to treat kidney problems; and a herbal tea made from the plant decreases flatulence. Extracts of *Bidens pilosa* are used in southern Africa to cure malaria. The Manyika people in the eastern highlands of Zimbabwe retain the first water used for cooking *Bidens pilosa* foliage for later use as a medicinal drink to cure stomach and mouth ulcers, diarrhoea, headaches and hangover. The Zulu in South Africa use a suspension of powdered leaves as an enema for abdominal trouble, whereas in Congo a concoction made from the whole plant is taken as a poison antidote, or to ease child delivery and to relieve the pain from hernia. In South Africa, strong decoctions of the leaf taken in large doses have been reported to be helpful in treating arthritis. In Côte d'Ivoire, the plant is used for treating jaundice and dysentery. The plant sap is applied to burns in Tanzania. In Nigeria, the powder or ash from the seed is used as a local anaesthetic and rubbed into cuts. The Giriama tribe from the coastal areas of Kenya use a leaf extract to treat swollen spleens in children. This tribe also uses a mixture of the dried and ground leaves of *Bidens pilosa*, soap and hot pepper as an insecticide for the control of leaf miners and other insects.

In Nanyuki, Kenya, *Bidens pilosa* is collected for the extraction of natural dyes. Among the Efe of DR Congo the root is washed and dried, then used as a painting brush. Livestock browses on the plants and in South Africa *Bidens pilosa* has been used as a fodder for pigs. However, dairy cattle are discouraged from browsing on it because the aromatic oil present in the plant has an objectionable smell that can taint milk. Chicken feed on the seed. In Uganda and in Mexico, the leaves are used as an invigorating or stimulant substitute for tea; while in the Philippines the flowers are used in the preparation of a kind of wine. The flowers are a good source of nectar for honey-bees.

Production and international trade Black jack as a vegetable and medicinal plant is frequently found in small quantities on local markets. The young plants or leaves and shoots are collected from the wild or from the field during weeding. In southern African countries it is usually found on the markets early during the rainy season when other fresh vegetables are scarce. Dried black jack leaves are especially important during periods of food scarcity in the dry season. Small-scale cultivation has been reported from Nigeria, Benin and Zimbabwe. There are no statistics on the total area under cultivation and the volumes traded. International trade has not been recorded.

Properties The composition of raw *Bidens pilosa* leaves per 100 g edible portion is: water 85 g, energy 180 kJ (43 kcal), protein 3.8 g, fat 0.5 g, carbohydrate 8.4 g, fibre 3.9 g, β-carotene 1800 μg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). Consumption as a raw vegetable is not recommended because of a high saponin content.

Extracts of *Bidens pilosa* show antimalarial activity both in vitro and in vivo. The crude ethanol extract (50 μg/ml) causes up to 90% inhibition of *Plasmodium falciparum* growth in vitro, compared with 86–94% inhibition for the chloroform fraction and 68–79% for the butanol fraction (both at 50 μg/ml). In vivo the crude ethanol extract and the chloroform fraction cause about 40% reduction of *Plasmodium berghei* parasitaemia in mice. Phenylacetylenes and flavonoids have been found in the ethanol extract from the leaves and the roots. The major component of the chloroform fractions from the roots was the phenylacetylene 1-phenylhepta-1,3-diyne-5-en-7-ol-acetate. The results indicate that the antimalarial activity of *Bidens pilosa* may be attributed to the presence of acetylene compounds. The direct therapeutic usefulness of these compounds seems limited, since they are easily oxidized by air and light.

Polyacetylenes also have antimicrobial activity. A number of polyacetylenes, e.g. phenylhepta-1,3,5-triyne from petroleum ether and methanol/water extracts of *Bidens pilosa* are toxic to yeasts and some bacteria. This compound is an active antiparasitic and exhibited marked insecticidal activity with LC_{50} of 204 ng/cm^2 for the first instar larvae of the fall army worm (*Spodoptera frugiperda*).

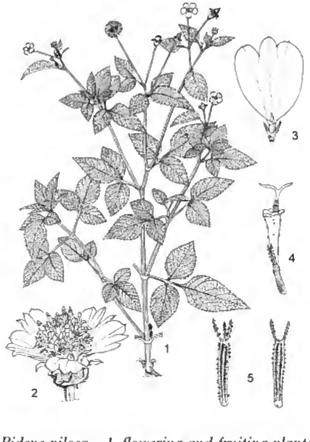
The polyacetylene 7-phenylhepta-2,4,6-triyne in combination with light is reported to be phytotoxic to fibroblast cells. Consumption of the leaves, as in South Africa, has been found to promote the development of oesophageal cancer, and dried leaves of *Bidens pilosa* have a co-

carcinogenic action for oesophageal tumours induced in rats.

In addition to the acetylenes, other compounds such as phytosterols (β-sitosterol), triterpenes (friedelin and friedelan-3β-ol) and caffeic acid(s) are also reported from *Bidens pilosa*. The main flavonoids from leaf extracts are aurones and chalcones. Since friedelin and friedelan-3β-ol, as well as several flavonoids have anti-inflammatory properties, their detection in extracts from *Bidens pilosa*, together with the presence of the described acetylenes, may explain the use of *Bidens pilosa* in traditional medicine, especially for treating wounds, against inflammations and against bacterial infections of the gastrointestinal tract.

The ethanolic extract of *Bidens pilosa* showed a high inhibition of prostaglandin synthesis in an in vitro assay for cyclo-oxygenase inhibitors. The methanol extract showed radio-protective activity for bone marrow. Besides the above-mentioned pharmacological activity, anti-hyperglycaemic, immunomodulator, anti-ulcer and hypotensive activity are reported.

Adulterations and substitutes *Bidens bipinnata* L., also called Spanish needles or black jack, is used as a substitute for *Bidens pilosa*. It differs by its bipinnatisect leaves.



Bidens pilosa – 1, flowering and fruiting plant; 2, flowering head; 3, ray floret; 4, disk floret; 5, achenes.
Source: PROSEA

Description Annual, erect herb up to 100 cm tall, with slender, stiff and 4-angled stems and spreading branches. Leaves decussately opposite, pinnately 3–5-foliolate, up to 15(–20) cm long, sometimes lower leaves simple, without stipules; leaflets with short petiolules, blade ovate to ovate-lanceolate, margins usually serrate or crenate-serrate, terminal leaflet larger than lateral leaflets. Inflorescence an axillary or terminal head 6–12 mm in diameter, solitary or arranged in lax cymes; outer involucral bracts 7–10, spatulate, 3–4 mm long, reflexed at anthesis, inner ones ovate-lanceolate. Ray flowers absent or 4–8, ligulate, sterile, corolla 7–15 mm long, white to yellow or pinkish; disk flowers tubular, bisexual, with 3.5–5 mm long, yellow corolla; stamens with fused anthers; ovary inferior, 1-celled, style bifid. Fruit a linear achene 4–13 mm long, 4–6-ribbed, with 2–3(–5) retrorsely barbed bristles of 2–4 mm long. Seedling with epigeal germination; hypocotyl elongated: cotyledons strap-shaped to spatulate.

Other botanical information *Bidens*, with its over 200 species, belongs to the tribe *Heliantheae* and is closely related to *Coreopsis*, with which some authors advocate uniting it. The taxonomy of *Bidens* is still unsatisfactory.

Bidens pilosa is a very variable species: plants are more or less erect, leaves simple to highly dissected, heads discoid to radiate, ray flowers yellow, pinkish or white and short to long, achenes awnless or with 2–5 bristles. Different ploidy levels seem to play a role.

Growth and development *Bidens pilosa* plants grow fast; flowering starts 6 weeks after emergence and continues until plant senescence 2–3 months later. Black jack is self-fertile but probably partly cross-pollinated by insects. The first seed is mature 4 weeks after flowering. Each plant bears at least 80 flower heads with a potential production of 3000 plants in a single generation and 4 generations per year. Seed harvested from central achenes has a higher germination rate than that harvested from the peripheral achenes. The fruits have tiny barbed hooks that enable them to readily stick on clothes and the coats of passing animals as a means of dispersal. Flowing water can also disperse the fruits.

Ecology Black jack grows freely in disturbed places, or as a weed in crops such as cereals, pulses and cotton, in sunny or slightly shaded places, from sea level up to 2400 m altitude.

The optimum temperature for germination is 25–30°C. Temperatures below 15°C and above 45°C are not favourable. It thrives in soils with a pH ranging from 4–9 and can tolerate a very high salinity, up to 100 mM NaCl. Flooding reduces seed emergence.

Propagation and planting *Bidens pilosa* is only sexually propagated. The weight of 1000 seeds (fruits) is about 1.4 g. The seed has no dormancy and germinates within 3–4 days in moist upper soil. Harvested fruits form large balls, which are difficult to disentangle, but after drying and storing for over three weeks, the barbed hooks break off easily. Dry seed is tough and remains viable for at least three years. The emergence is good when seed is buried not more than 4 cm in the soil. The seed will not germinate if buried at more than 6 cm. Soaking of the seed in water increases germination.

Management *Bidens pilosa* is a weed in both field and plantation crops and is recorded as troublesome in about 30 crops in more than 40 countries, including about 20 African countries. It is considered one of the most noxious annual weeds in East Africa. It often becomes dominant after the eradication of perennial grasses, and displays allelopathic effects on a number of crops.

Black jack is a semi-cultivated plant in compounds where selective weeding is applied. Cultivation is easy. The seed is sown broadcast or in rows and the seedlings thinned out to 10–15 cm. As a vegetable, the plants are ready for harvesting within 4–6 weeks of emergence, before seed setting. There may be 4 or 5 successive plantings within a year. If black jack is grown for harvesting the leaves as antimalaria medicine, deflowering is necessary to retard senescence and maintain growth.

Diseases and pests Very few records of pests and diseases have been recorded on this plant. In Nigeria the following were observed: a virus causing greyish-green and lumpy leaves, plants remaining small and flowering early; *Cercospora bidentis* leaf spot; leaf miners in older leaves; larvae of the moth *Perigea pauperata*, 20–30 mm long and pale greenish with a yellow head, sheltering in leaves bound together.

Harvesting In cultivation, the first harvest is 4–6 weeks after sowing, when the plants are 15–30 cm high. Harvesting is done by hand picking, cutting or uprooting. If the plants are topped, a second harvest can follow after 2 weeks. Up to 6 harvests are possible.

Yield The yield is up to 3 kg/m^2.

Handling after harvest Tender leaves, shoots or whole young plants are washed and tied into bundles, after which they may be taken to the market. Although they are not as perishable as most leafy vegetables, the leaves intended for marketing are harvested late during the day or early in the morning so that they remain fresh for marketing. Leaves may also be parboiled and then dried in the sun for later use. Leaves, stems, roots and seed intended for medicinal purposes do not require any delicate handling.

Genetic resources In view of its widespread distribution and weedy nature, *Bidens pilosa* is not at risk of genetic erosion. Its wide variability in morphology and cytology indicates much genetic variation, which warrants more research.

Prospects There does not appear to be a high need for commercial cultivation of black jack because it occurs abundantly as a weed. Cultivation might even promote its spread as a weed. The traditional application of *Bidens pilosa* in local medicine, especially for its antiseptic and anti-inflammatory properties, will remain of importance, the more so as the plants are readily available. The immunomodulatory, anti-inflammatory and especially antimalarial properties deserve further attention.

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Other references Benhura, M.A.N. & Chitsiku, I.C., 1997; Chivhinge, O.A., 1996; Hind, D.J.N., Jeffrey, C. & Scott, A.J., 1993; Humbert, H., 1963; Latham, P., 2000; Mariano, A.C. & Marin-Morales, M.A., 1998; Mesfin Tadesse, 1994a; Morton, J.F., 1962; Nesamvuni, C., Steyn, N.P. & Potgieter, M.J., 2001; Pereira, R.L.C. et al., 1999; Reddy, K.N. & Singh, M., 1992; Rocha, O. J., 1996; van der Zon, A.P.M. & Grubben, G.J.H., 1976; Zobolo, A.M. & van Staden, J., 1999.

Sources of illustration Alonzo, D.S. & Hildebrand, J.W., 1999.

Authors B. Mvere

BIDENS SCHIMPERI Sch.Bip.

Protologue Repert. Bot. Syst. 6: 168 (1846).

Family Asteraceae (Compositae)

Origin and geographic distribution *Bidens schimperi* is found throughout eastern Africa from southern Egypt to South Africa. It is particularly common in the highlands of Tanzania and Zimbabwe.

Uses The leaves are eaten as a vegetable in Tanzania. They are chopped and cooked alone or with other vegetables such as peas or pumpkin leaves. Coconut milk, groundnut paste, tomatoes and onions are often added to improve the palatability. In Malawi the young shoots are broken up into small pieces and cooked as a vegetable, often together with black jack (*Bidens pilosa* L.). The product is very bitter and not much liked.

In Tanzania the roots are used to treat chest pains, coughs and colds, and *Bidens schimperi* is also valued there as an ornamental, fodder and bee forage.

Botany Annual, erect herb up to 1(–1.5) m tall, with 4-angled stems, sometimes branched. Leaves opposite, rarely alternate towards the upper part of the plant, usually tripartite, 20(–30) cm × 10(–15) cm; leaf segments ovate or narrowly oblong-ovate, margins entire, lobed, incised-dentate or crenate-serrate. Inflorescence a head 2.5–4 cm in diameter, arranged in lax cymes; outer involucral bracts 8, 2.5–10 mm long. Ray flowers 6–8, sterile, corolla 6–20 mm long, yellow; disk flowers tubular, bisexual, with c. 4 mm long, yellow corolla. Fruit a linear achene up to 16 mm long, 4-ribbed, with (1–)2 retrorsely barbed bristles up to 4 mm long.

The genus *Bidens* in Africa comprises 63 species. The African species, formerly considered to belong to the genus *Coreopsis*, are now all placed in *Bidens*.

Ecology In Tanzania *Bidens schimperi* is common in dry grassland, on black cotton soil, in abandoned fields and overgrazed or recently burnt grassland, from sea-level up to 2400 m altitude.

Genetic resources and breeding As it is widespread and locally common, *Bidens schimperi* is not at risk of genetic erosion.

Prospects *Bidens schimperi* is likely to remain a locally important vegetable in areas where it is common during periods when other vegetables are scarce. Because of its weedy nature it should not be promoted as an ornamental outside the area of distribution. Traditional medicinal uses will continue to be important locally.

Major references Alonzo, D.S. & Hildebrand, J.W., 1999; Mesfin Tadesse, 1984; Ruffo, C.K., Birnie, A. & Tengnäs, B., 2002; Williamson, J., 1955.

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Authors C.H. Bosch

BORASSUS MADAGASCARIENSIS Bojer ex Jum. & H.Perrier

Protologue Ann. Inst. Bot.-Géol. Colon. Marseille sér. 3, 1(1): 61 (1913).

Family Arecaceae (Palmae)

Synonyms *Borassus flabellifer* L. var. *madagascariensis* Jum. & H.Perrier (1907).

Vernacular names Madagascar Palmyra palm (En). Rônier de Madagascar (Fr).

Origin and geographic distribution *Borassus madagascariensis* is endemic to Madagascar.

Uses The palm heart is eaten. The newly germinated seedlings are eaten fresh, or cooked into a sort of gruel that is much relished. The stem pith gives a slightly bitter sago-like substance that is also consumed. The hollowed-out stems were formerly used as containers. An alcoholic drink is produced from the fruit. There are no reports of the production of palm wine from *Borassus madagascariensis*, in contrast with the *Borassus* species of the African mainland, which are well-known sources of this. *Borassus madagascariensis* is occasionally grown as an ornamental.

Properties The seeds contain an oil that is rich in unsaturated fatty acids. No other data are available on the chemical composition of *Borassus madagascariensis*. However, young shoots of the related species *Borassus flabellifer* L. from mainland Africa, which is mainly used for the production of palm wine, contain per 100 g edible portion: water 69.5 g, energy 431 kJ (103 kcal), protein 2.7 g, fat 0.2 g, carbohydrate 24.4 g, fibre 2.2 g, Ca 18 mg, P 140 mg, thiamin 0.05 mg, riboflavin 0.18 mg, niacin 0.9 mg, ascorbic acid 8 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968).

Botany Palm with solitary trunk 10–16 m tall, 40–60 cm in diameter, with a swelling of up to 75 cm at or above the middle. Leaves 12–20 in crown, arranged spirally, up to 5 m long, palmately compound; petiole 2–3 m long; segments 60–95, 1.2–2 m × 4–9 cm, undulating.

Inflorescence unisexual; male inflorescence c. 1.5 m long, branched to 1–2 orders, with 4–14 partial inflorescences, peduncle 20–60 cm long, bracts 2–4, up to 40 cm long; female inflorescence unbranched, c. 1.2 m long, peduncle c. 35 cm long, bracts 9–10, up to 50 cm long. Flowers unisexual, 3-merous; male flowers with 6 stamens; female flowers with superior, 3-celled rounded ovary. Fruit a subglobose drupe 15–18 cm in diameter; pyrenes 3, shaped as one-third of a globe, c. 12 cm × 8–12 cm × 5–7 cm. Seeds 6.5–8.5 cm × 7–7.5 cm × 5–5.5 cm.
Borassus sambiranensis Jum. & H.Perrier, also from Madagascar and possibly conspecific with *Borassus aethiopum* Mart., has similar uses as *Borassus madagascariensis*.

Ecology *Borassus madagascariensis* occurs along rivers on alluvial soils at low altitudes.

Management *Borassus madagascariensis* is reproduced through seeds. These are to a limited extent traded on the international market. There are about 3 seeds in one kg.

Genetic resources and breeding The conservation status of *Borassus madagascariensis* is rated as 'vulnerable' on the IUCN red list of threatened plants. Although known from several sites, the original habitat over the entire distribution area has been almost totally destroyed. There are no known germplasm collections.
In addition to about 15 individuals in the Sambirano area in Madagascar, just a few trees of *Borassus sambiranensis* are known from Mayotte.

Prospects *Borassus madagascariensis* is an attractive palm, but with no special qualities compared to the more common *Borassus aethiopum*. The uses are only of local importance. *Borassus sambiranensis* often has a characteristic bulge in the middle of the trunk, also observed in East African *Borassus aethiopum*, which renders it more interesting as an ornamental. The collection of seeds from the wild for the purpose of international trade must be discouraged.

Major references Burkill, H.M., 1997; Dransfield, J. & Beentje, H.J., 1995; Jumelle, H., 1945; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Rabarisoa, I., Bianchini, J.P. & Gaydou, E.M., 1988.

Other references Davies, R.I. & Pritchard, H.W., 1998; Haynes, J. & McLaughlin, J., 2000; IUCN, 2002; Johnson, D.V., 1996; Walter, K.S. & Gillett, H.J., 1998.

Authors W.J. van der Burg

BRASSICA CARINATA A.Braun

Protologue Flora 24: 267 (1841).
Family Brassicaceae (Cruciferae)
Chromosome number $2n = 34$
Synonyms *Brassica integrifolia* (H.West) Rupr. var. *carinata* (A.Braun) O.E.Schulz (1919).

Vernacular names Ethiopian kale, Ethiopian mustard, Ethiopian rape, Abyssinian mustard (En). Chou éthiopien, moutarde d'Abyssinie (Fr). Figiri (Sw).

Origin and geographic distribution *Brassica carinata* is an amphidiploid with one genome from *Brassica nigra* (L.) Koch and the other from *Brassica oleracea* L. Ethiopia is the centre of genetic diversity of *Brassica carinata*, and its cultivation is thought to have started there about 4000 years BC. Truly wild types are not known, but *Brassica carinata* often escapes from cultivation. In the literature it has been much confused with *Brassica juncea* (L.) Czern., and therefore its exact distribution in Africa is difficult to indicate. The cultivation of *Brassica carinata* as an oil crop is restricted to Ethiopia, but as a leafy vegetable it is often grown in East and southern Africa, less so in West and Central Africa.

Uses In most parts of Africa, the primary use of *Brassica carinata* is as a cooked leafy vegetable, whereas in Ethiopia, where it is called 'gomen zer' in Amarinya, the seed oil is of major importance too. Outside Africa, especially in western and southern Asia, it is occasionally grown as an oilseed crop or for mustard. The seeds are crushed and the oil is used for cooking and in the mustard industry. The oil has limitations for cooking because of high contents

Brassica carinata – planted and naturalized

of glucosinolates and erucic acid. In Ethiopia it is used for oiling the baking plates of earthenware 'injera' stoves. It is also used for illumination. The seed is used in folk medicine to treat stomach-ache. People in Ethiopia use the sharp-tasting seeds as a spice to flavour raw meat. The crop is occasionally used as fodder for livestock and the seeds to feed birds. The seed cake is used as high protein food for animals, although the presence of glucosinolates is a limiting factor. Of late, there has been an interest in utilizing the oil, like other *Brassica* seed oils, as a biodiesel and for the preparation of special erucic acid derivatives.

Production and international trade Production of *Brassica carinata* for its seed is important only in Ethiopia; production in Canada and the Mediterranean region is still mainly experimental. As a leafy vegetable it is mostly grown as a kitchen garden crop, although in Tanzania, Malawi, Zambia and to a lesser extent in Zimbabwe it is also grown as a market crop. Its use as a leaf crop appears to be declining because of higher yielding leaf cabbage (*Brassica oleracea*) and leaf mustard (*Brassica juncea*). No statistical data on its production are known.

Properties There is no information on the nutritional composition of *Brassica carinata* leaves, but it is probably comparable to *Brassica juncea*. The seeds are rich in oil, containing 25–47% depending on cultivar and growing conditions; the protein content is also high, 25–45% and comparable to that of pulses. The oil consists of: erucic acid 35–44%, linoleic acid 15–22%, linolenic acid 16–20%, oleic acid 10–12%, eicosenoic acid 7–9% and palmitic acid 2–4%. Lines containing oil without erucic acid have been developed through cross-breeding with *Brassica juncea* and *Brassica napus* L. and through mutagenesis. The seeds have a high content of glucosinolates (100–200 µmoles/g), almost exclusively sinigrin, which has antioxidant but also goitrogenic properties. The phytoalexin brassilexin and several of its precursors are synthesized by *Brassica carinata* in response to attack by the blackleg pathogen *Leptosphaeria maculans*, which may explain its resistance to it.

Adulteration and substitutes The *Brassica carinata* leaf crop can be replaced by the various types of leaf cabbage (*Brassica oleracea*) or leaf mustard (*Brassica juncea*), the seed crop by *Brassica juncea*, *Brassica napus* or *Brassica nigra*.

Description Erect, annual or occasionally biennial or perennial herb up to 150(–200) cm tall, usually branched, glabrous to slightly hairy at stem and petiole bases, slightly glaucous; taproot strong. Leaves alternate, usually simple, lower ones sometimes with 1 pair of small side lobes at base; stipules absent; all leaves with short petiole; blade obovate, up to 20 cm × 10 cm, double-crenulate but upper ones often more or less entire. Inflorescence initially a rather loose umbel-like raceme but soon elongating, up to 50 cm long. Flowers bisexual, regular, 4-merous; pedicel ascending, 5–12 mm long; sepals oblong, 4–6(–7) mm long, green; petals obovate, 6–10 mm long, clawed, pale to bright yellow; stamens 6; ovary superior, cylindrical, 2-celled, stigma globose. Fruit a linear silique 2.5–6 cm × 2–3.5 mm, often somewhat constricted between the seeds, with a conical beak 2–6(–7) mm long, dehiscent, up to 20-seeded. Seeds globose, 1–1.5 mm in diameter, finely reticulated, pale to dark brown. Seedling with epigeal germination, with a strong main root and fibrous lateral roots; hypocotyl 2–3 cm long, epicotyl very short; cotyledons broadly obovate, c. 2.5 cm long, dark green.

Brassica carinata – 1, habit of young plant; 2, flowering and fruiting branch; 3, fruit.
Redrawn and adapted by Iskak Syamsudin

Other botanical information Three wild

Brassica species are found in the Mediterranean region: *Brassica nigra* (L.) Koch (black mustard) with the basic chromosome number $n = 8$ (B genome), *Brassica oleracea* L. (cabbage) with $n = 9$ (C genome) and *Brassica rapa* L. (turnip) with $n = 10$ (A genome). *Brassica carinata* is considered an amphidiploid hybrid between *Brassica nigra* and *Brassica oleracea*, with genomes BBCC, $2n = 34$. The hybridization may have occurred on several occasions; genetic evidence indicates that in all cases *Brassica nigra* has been the female parent. *Brassica juncea* is an amphidiploid hybrid between *Brassica nigra* and *Brassica rapa* with $2n = 36$. It is often confused with *Brassica carinata* and information can not always be attributed to either of these species with certainty. The lower leaves of *Brassica juncea* usually have more lobes and its fruit beak is longer (usually > 6 mm).

Growth and development The time from sowing to emergence of the seedling is about 5 days, depending on temperature and soil moisture. Plants develop an extensive root system, larger than in other *Brassica* species. In general, large-leaved cultivars have fewer branches than small-leaved ones. There is a difference in first flowering date between oil types and vegetable types; oil types start flowering about 10 weeks after germination, vegetable cultivars after about 12 weeks, depending on cultivar and growing conditions. Flowering of vegetable cultivars is delayed by regular harvesting of leaves or young shoots. Plants grown in dry regions flower earlier and produce ripe seeds within 4 months from sowing. Vegetable crops grown with adequate moisture produce seeds in 5–6 months. Some tall cultivars, when grown with adequate moisture, may develop new shoots after removal of the infructescences and become perennial, normally for one further season, but plants of up to 4 years old have been recorded. Most *Brassica* species are cross-pollinating, which contributes to the great diversity within species. *Brassica carinata* is an exception as it sets seed very efficiently through self-pollination without insects acting as pollinators. It does not need low temperatures for flower initiation, and seed production is therefore much easier in Africa than for most *Brassica oleracea* leaf cabbages except for Portuguese kale.

Ecology Ethiopian kale is rather versatile and can be found in highland regions up to 2600 m with a cool climate, but also in lowlands with relatively warm and dry conditions. It grows best in the dry season under irrigation when there are few pests and diseases. The crop is suited to a wide range of soils and especially the oil crop is often grown in marginal areas; the vegetable crop is mostly grown on more fertile soils. Ethiopian kale can grow from the equator to Canada and appears to be daylength neutral. It is sensitive to salt and seeds may not germinate in soils with an above average salinity level. Waterlogging is not tolerated.

Propagation and planting Propagation is normally by seed and rarely through cuttings. The weight of 1000 seeds is 3–5 g. When grown for the leaves, sowing in a nursery and transplanting are widely practised. Seedbeds are normally raised above the soil to reduce the incidence of damping off. The top layer is dug and some well-fermented manure is worked in to produce a friable soil. Seeds are drilled in the nursery in lines 15–20 cm apart. Watering in the nursery should be done with a fine rose. Farmers may cover the seedbeds with long grass or similar material to keep the surface moist and dark. When the cotyledons have spread after germination, this mulch is removed or placed next to the plantlets. Seedlings can be transplanted at the 4-leaf stage, about 5 weeks after germination. When seedlings become too tall, they may become spindly and unlikely to develop into strong plants. The field spacing is about 35–40 cm within and 50–60 cm between rows, depending on the plant size. Near Nairobi (Kenya) the space between rows is interplanted with shallot, parsley and the leafy vegetable *Crotalaria* sp. When grown as an oil crop, seeds are sown directly in lines or broadcast when a short-duration leaf crop is aimed for.

Management Ethiopian kale responds well to organic manure of up to 20 t/ha. Most farmers find it easier to incorporate chemical fertilizers in the plant beds at the rate of about 100 kg N and 30 kg P. Higher levels of nitrogen will increase proteins and enhance leaf production, whereas more phosphorous will enhance the seed production potential. Some vegetable farmers will therefore increase the initial amount to 300 kg N, whereas others give a fortnightly side dressing of 50 kg N at a time. For oilseed production, all fertilizers are incorporated at planting and no topdressing is given. For leaf production regular irrigation is necessary when it is not raining since water stress induces early flowering. When the crop is sown at the onset of the rains, attack by

pests and diseases will be severe. To avoid such attacks, it is recommended that the crop be sown 5–6 weeks before rains are expected so that the crop can be transplanted at the onset of the rains.

Diseases and pests Ethiopian kale is sensitive to turnip mosaic virus (TuMV) and especially the leaf crop is vulnerable. TuMV is transmitted by a range of aphids, of which the cabbage aphid *Brevicoryne brassicae* and the green peach aphid *Myzus persicae* are the most important. Oilseed types with bluish leaves have a thicker layer of leaf wax than green-leaved vegetable types and it has been noticed that leaf wax keeps aphids at bay to some extent. Leaf wax is also associated with the level of tolerance to Alternaria leaf spot (*Alternaria brassicae*). Ethiopian kale is susceptible to black rot (*Xanthomonas campestris*), black spot (*Alternaria brassicicola*), and to damping off and seedling root rot (*Rhizoctonia solani*). Cultivar 'Nanga' from Zambia has shown tolerance to black rot. Ethiopian kale is tolerant to black leg disease *Leptosphaeria maculans* (asexual form: *Phoma lingam*). White rust (*Albugo candida*) is mainly found on vegetable cultivars, but not in the oil crop. *Xanthomonas*, *Alternaria*, *Phoma* and *Rhizoctonia* are seedborne diseases, so a reliable seed source is most important, but these diseases are also retained in the soil so appropriate crop rotation is also essential. To avoid black rot, production during the rainy season is not recommended. The best disease control is proper management rather than a spraying regime with agro-chemicals.
Diamondback moth (*Plutella xylostella*) is less problematic on Ethiopian kale than on cabbages and cauliflower. Other pests include caterpillars of the cabbage butterfly (*Pieris brassicae*) and the grubs of mustard sawfly (*Athalia proxima*), a pest that is particularly important at the seedling stage. Other pests are the cabbage and mustard aphid (*Hyadaphis pseudobrassicae*, synonym: *Lipaphis erysimi*), cabbage weevil (*Lixus* sp.), flea beetles (*Phyllotreta* spp.), and hurricane bug (*Bagrada cruciferarum*).

Harvesting There are several ways to harvest this vegetable. Plants from seeds that were broadcast at high density can be harvested by uprooting the whole plant 6 weeks after sowing. This method is normally used when the land is needed for another crop. For a conventional crop, the first harvest takes place about 5 weeks after transplanting. Leaf harvesting is best done once in 2 weeks with 50% defoliation. Small-leaved cultivars are often collected in the form of shoots rather than as individual leaves.
Seed crops are harvested when the fruits turn brown. Infructescences are cut and placed on a tarpaulin or similar sheet, where they are allowed to dry without risk of seed shattering. The crop is then threshed and winnowed.

Yield The farmer can expect an average leaf and shoot yield of 35 t/ha, but at research stations leaf yields of 50–55 t/ha have been reported, depending on production season and cultivar. In India and Canada farmers may get seed yields of 1200–1800 kg/ha in a good year.

Handling after harvest The leaves are rather perishable and wilt or become yellow when left on the shelf for more than a day. Farmers therefore harvest small quantities at a time. To retain freshness, the leaves are kept moist inside a bag that is left in the shade or in a cool place. When the product is offered as whole plants with roots, traders place the roots in water and plants can thus be kept for a few days.

Genetic resources The genetic diversity in *Brassica carinata* based on molecular DNA markers is much less than in *Brassica juncea*. In spite of the comparatively small variation in *Brassica carinata*, there are many landraces for both the oilseed and the leafy vegetable types, differing in earliness, plant structure, leaf size, shape and structure, seed yield, and glucosinolate and erucic acid levels in the seed. There is a need for further collection, conservation and evaluation of this diversity before farmers start using new cultivars at the expense of their traditional landraces. A collection is maintained at the Centre for Genetic Resources (CGN), Wageningen, Netherlands. Working collections are available at research institutes in Ethiopia, Tanzania, Zambia and Zimbabwe.

Breeding In Africa some breeding work has been done and several selections have been made in Tanzania, Zambia and Zimbabwe. Selection criteria are leaf size, late bolting, reduced susceptibility to major diseases and pests, and high yield. Well-known cultivars are 'White Figiri', 'Purple Figiri', 'Lushoo', 'Mbeya Green' and the large-leaved 'Lambo' from Tanzania, 'RRS-V' from Zimbabwe, 'Chibanga' and 'NIRS-2' from Zambia. 'TAMU Tex Sel' is a vegetable cultivar released in Texas (United States). In Zambia, Ethiopian kale has been crossed with Portuguese cabbage and with *Brassica nigra*. More breeding work has taken

place on cultivars used for oilseed, mainly in Canada, India and Italy. Low erucic acid and glucosinolate content and high seed yield are major selection criteria.

Prospects Ethiopian kale is a leafy vegetable and oil crop that is fully adapted to African conditions and has a high potential. There are many different landraces, allowing the breeder ample scope for advancement. Seed production by farmers themselves is easy, but the availability of reliable and healthy commercial seed would also benefit farmers. If no action is taken soon, this species will gradually disappear, and be replaced by new cultivars of especially *Brassica juncea* and loose-leaved types of *Brassica oleracea*, for which more research has been done and which receive more attention from breeders.

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Sources of illustration Jonsell, B., 1982a; Jonsell, B., 2000.

Authors N.A. Mnzava & R.R. Schippers

BRASSICA JUNCEA (L.) Czern.

Protologue Consp. pl. charc.: 8 (1859).

Family Brassicaceae (Cruciferae)

Chromosome number $2n = 36$

Synonyms *Sinapis juncea* L. (1753).

Vernacular names Brown mustard, Indian mustard, leaf mustard (En). Moutarde brune, moutarde de Sarepta, moutarde de Chine, moutarde frisée (Fr). Mostarda vermelha, mostarda indiana (Po). Haradali, mastadi (Sw).

Origin and geographic distribution *Brassica juncea* is an amphidiploid with *Brassica nigra* (L.) Koch ($2n = 16$) and *Brassica rapa* L. ($2n = 20$) as parents. Several regions in western and central Asia have been assumed to be the centre of origin of *Brassica juncea*. Brown mustard has been cultivated in Asia and Europe for thousands of years for its leaves and seeds. Presently, vegetable types of *Brassica juncea* are cultivated throughout southern and eastern Asia. Variation is greatest in China. Brown mustard is grown as a leafy vegetable in West and southern Africa, known as 'laulau' in Nigeria, 'mpiru' in Malawi and 'tsunga' in Zimbabwe. In many African countries it has been introduced and became naturalized. However, its exact distribution in Africa is difficult to indicate because of confusion with other *Brassica* species, especially *Brassica carinata* A.Braun. Oilseed types are particularly important in southern Asia, China, North America and Europe, but are not or only rarely found in Africa. *Brassica juncea* is important as a source of mustard in Europe and North America, and it is occasionally planted for this purpose in Africa, e.g. in Réunion and Mauritius.

Brassica juncea – *planted and naturalized*

Uses *Brassica juncea* has many uses: it yields a seed oil, crushed seed is used in the production of mustard and it has a variety of vegetable uses. It is also used as forage and medicinally.

In Africa and many parts of Asia the leaves are eaten as a vegetable; they are often shredded, cooked and served as a side dish with the staple food. Older leaves and leaves affected by drought are very bitter. When they have to be used, consumers renew the cooking water once. Young tender leaves, called 'mustard greens'

are used in salads, mixed with other salad greens. In Asia brown mustard leaves are used in pickles or offered as frozen or canned vegetables. Sprouted seeds are used as a garnish or to add a spicy note to salads. In East Asia a variety of vegetable types have been developed that are comparable to that of *Brassica oleracea* L. 'Tai Tau Choi' has an enlarged root and is prepared and eaten like turnips, while 'Cha Tsoi' has peculiar swollen stems with knobby bulges that are preserved in brine and pressed flat until most of the sap is removed.

In Asia, Europe and America, *Brassica juncea* is grown mainly for its seed used in the fabrication of brown mustard or for the extraction of vegetable oil. It has been introduced for this purpose locally in Africa, e.g. in the Mascarene Islands. In much of Europe *Brassica juncea* has replaced *Brassica nigra* as the main source of commercial mustard seed. Its mustard is spicier than the yellow type made from *Brassica nigra*. Mustard oil is one of the major edible oils in Bangladesh, India and Pakistan, appreciated for its special taste and pungency. In adjacent parts of the former Soviet Union it is used as a substitute for olive oil. In Western countries its use as edible oil is restricted because of the high erucic acid content. The oil is also used as hair oil and as lubricant. The oil of cultivars bred for extra high erucic acid content is used for industrial purposes. A peculiar use of mustard oil is to retard the fermentation process when making cider from apples. The seeds are also used in birdseed mixtures. The remaining seed meal is high in protein, but the high glucosinolate content makes it unacceptable for human or for monogastric-animal consumption.

Brown mustard is reported to have anodyne, aperient, diuretic, emetic and rubefacient properties. It is a folk remedy for arthritis, foot ache, lumbago and rheumatism. In China the seed is used as medicine against tumours. Ingestion may impart a body odour repellent to mosquitoes. Leaves applied to the forehead are said to relieve headache. The leaves are eaten in soups to treat bladder inflammation or haemorrhage. In Korea the seeds are used to treat abscesses, colds, lumbago, rheumatism and stomach disorders. Brown mustard oil is used against skin eruptions and ulcers. In Tanzania the roots have been given to cows to promote milk production.

Production and international trade Statistics on the production and trade of seed oil and mustard of *Brassica juncea* are difficult to find as they are often combined or confused with those of rape seed (*Brassica napus* L. or *Brassica rapa* L.). Brassica oil is the third-most important vegetable oil after only soya bean and oil palm. Brown mustard as a vegetable is only marketed locally even in those parts of Asia where it is an important vegetable. In Africa it is mainly encountered in southern Africa and is quite rare elsewhere. In Zambia and Zimbabwe, where it is referred to as 'rape', it is very popular, but no reliable statistics are available on the area under cultivation, production or produce traded.

Properties Brown mustard leaves contain per 100 g edible portion: water 90.8 g, energy 109 kJ (26 kcal), protein 2.7 g, fat 0.2 g, carbohydrate 4.9 g, total dietary fibre 3.3 g, Ca 103 mg, Mg 32 mg, P 43 mg, Fe 1.46 mg, Zn 0.2 mg, vitamin A 10,500 IU, thiamin 0.08 mg, riboflavin 0.11 mg, niacin 0.80 mg, folate 187 μg , ascorbic acid 70 mg. Dry mustard seed contains per 100 g edible portion: water 6.9 g, energy 1964 kJ (469 kcal), protein 24.9 g, fat 28.8 g, carbohydrate 34.9 g, Ca 521 mg, Mg 298 mg, P 841 mg, Fe 10.0 mg, vitamin A 62 IU, thiamin 0.54 mg, riboflavin 0.38 mg, niacin 7.9 mg, ascorbic acid 3 mg (USDA, 2003).

The seeds and leaves contain the glucosinolate sinigrin. Their pungency develops when cells are damaged and sinigrin is hydrolyzed by the enzyme myrosinase to form allyl isothiocyanate. The seed also contains sterols of which the most important ones are brassicasterol, campesterol and sitosterol. The oil content of the seed is 28–45% with an average of about 35%. The oil is similar to that of other *Brassica* species and is made up of erucic acid 25–55%, oleic acid 8–33%, linoleic acid 12–21%, linolenic acid 8–14%, eicosenoic acid 6–12%, palmitic acid 2–4%, stearic acid 0.8–1.5%, arachidic acid 0.5–1.2%, palmitoleic acid 0.2–0.5%, nervonic acid 0–2%, behenic acid 0–1% and lignoceric acid 0–1%. Eicosenoic acid and erucic acid are long-chain fatty acids that have antinutritional and toxic properties. Cultivars yielding oil low in eicosenoic acid and erucic acid have been developed. Their fatty acid composition is: palmitic acid 56%, stearic acid 25%, arachic acid 10%, behenic acid 6% and lignoceric acid 3% (USDA 2002). They are generally recognized as safe for human consumption. Together with cultivars of *Brassica napus* and *Brassica rapa*, yielding similar oil, they are known in Canada as 'canola'. The seed cake remaining after oil extraction contains about 37% crude protein.

Experiments with rats suggest that brown

mustard might be beneficial in attenuating the damage caused by oxidative stress involved in diabetes and its complications.

Adulterations and substitutes Mustard leaves are often erroneously called 'rape leaves', but rape (*Brassica napus*) is a distinct vegetable and oil crop. Brown mustard as leafy vegetable can easily be replaced by leaf cabbages (special cultivars of *Brassica oleracea*, *Brassica carinata* and *Brassica napus*), although these lack the typical taste of brown mustard.

Description Erect, annual to biennial herb up to 160 cm tall, often unbranched, sometimes with long ascending branches in upper part, almost glabrous to scattered hairy, slightly glaucous; taproot sometimes enlarged (root mustard). Leaves alternate, pinnately lobed but upper ones often simple; stipules absent; all leaves with short petiole; blade ovate to lanceolate or with up to 2 side lobes on each side and a large end lobe, up to 30 cm × 10 cm, margin irregularly toothed. Inflorescence initially an umbel-like raceme but soon strongly elongating, up to 60 cm long. Flowers bisexual, regular, 4-merous; pedicel ascending, 5–12 mm long; sepals oblong, 4–6 mm long, green; petals obovate, 6–10 mm long, clawed, bright yellow; stamens 6; ovary superior, cylindrical, 2-celled, stigma globose. Fruit a linear silique 2.5–7.5 cm × 2–3.5 mm, often constricted between the seeds, with a conical beak usually longer than 6 mm, dehiscent, up to 20-seeded. Seeds globose, 1–1.5 mm in diameter, finely reticulate, pale to dark brown.

Brassica juncea – 1, flowering branch; 2, flowering and fruiting branch; 3, seed.
Source: PROSEA

Other botanical information *Brassica juncea* is a highly variable species which has been cultivated for centuries as a vegetable and oil plant, and is also a widespread weed. *Brassica juncea* cultivars have only slightly glaucous, often dark green and more or less hairy leaves, distinct from the bluish green, glabrous leaves of the other leaf brassicas. In Africa it has been much confused with *Brassica carinata*, but the lower leaves of the latter species are simple or have up to 1 side lobe on each side, and its fruit beak is shorter (usually < 6 mm).

Several authors have proposed cultivar classifications for *Brassica juncea*. These have little relevance for Africa, where farmers use mostly local cultivars. Only occasionally is seed imported from Western seed companies, e.g. 'Florida Broad Leaf'.

Growth and development Seed germinates within 5 days after sowing at 20–25°C. Under good conditions plants grow rapidly and leaves are harvestable after 3 weeks when plants have developed 6–8 fully expanded leaves, but harvesting will start later when larger leaves are demanded for sale. Under tropical African conditions, flowering occurs early as low temperatures are not required for flower induction. Water stress or low soil fertility promote early flowering. *Brassica juncea* is self-fertile, but bees may effect cross-pollination. Fruits develop rapidly and the seeds can be ready for harvesting within 4 weeks from flowering.

Ecology Brown mustard is reported to tolerate annual precipitation of 500–4000 mm and temperatures of 6–37°C and is therefore suited to the tropical lowlands as well as relatively cool conditions. It grows best on fertile, well-drained loamy soils with a pH of 5.5–6.8, rich in organic matter. At high temperatures it will quickly flower and yields are lower, but production is still possible. For seed production, brown mustard is tolerant of adverse conditions including moisture stress, high or low pH, salt and insect damage.

Propagation and planting Brown mustard can be sown directly or transplanted. Direct

sowing is mainly used when time is a limiting factor and where there is a market that will accept smaller leaves. This system is frequently used in Zambia in wet areas called 'dambos'. The weight of 1000 seeds is 1.7–2 g. The seeds need to be mixed with sand and broadcast thinly to avoid the need for removing too many seedlings later on. The first harvest can be in the form of thinned-out seedlings, collected after about 35 days from sowing. Transplanting is common and seedlings are raised in 1 m wide nursery beds with fertile finely-tilled soil. Seed beds should be prepared by loosening the soil and incorporating up to 50 kg of well-fermented manure per 10 m^2. Seed is sown in drills 25–30 cm apart and seedlings are thinned to a spacing of 5–10 cm. Seedlings need to be adequately watered. They are ready for transplanting after 20–30 days when they have 3–4 true leaves, and are planted at a spacing of 30–50 cm between rows and 20–40 cm in the row, depending on the size of the plant required. When grown as an oil crop, seeding is at a rate of 4–6 kg/ha. Plant density may vary as brown mustard has a considerable capacity to compensate for an irregular plant stand.

Management The uptake of minerals by brown mustard is high and manure application to the field at a rate of 30 t/ha is recommended. When no manure is available, it can be replaced by a fertilizer gift of about 500 kg/ha NPK 18–12–12, depending on soil fertility. Top dressing of N-fertilizer is practised a few weeks after transplanting. For seed production fertilizer applications may be lower. Weeding is required during the early growth stages of leaf mustard and ample watering is necessary to promote rapid growth. Early flowering can occur during hot weather with high temperatures. In several parts of the United States *Brassica juncea* is considered a noxious and invasive weed

Diseases and pests A devastating disease of brown mustard during the rainy season is bacterial soft rot (*Erwinia carotovora*), for which there is no adequate control. Another bacterial problem is black rot caused by *Xanthomonas campestris*, a disease that is both soilborne and seedborne. Amongst the fungal diseases, the most important is Alternaria black spot (*Alternaria brassicae* and *Alternaria brassicicola*). Turnip mosaic virus (TuMV) is also noticed quite frequently on brown mustard.
The most destructive pest is diamondback moth (*Plutella xylostella*), especially during the dry season. Other pests are cabbage web worm (*Hellula undalis*), caterpillars of the mustard leaf webber (*Crocidolomia binotalis*), aphids and flea beetles (*Phyllotreta* spp.) and several nematodes. In cold weather brown mustard has few pests, but warmer weather will bring on aphids and other insects.
Field sanitation, rotation with unrelated crops and the use of pathogen-free seeds considerably reduce the impact of pests and diseases. However, under conditions of subsistence production little is done to control pests and diseases.

Harvesting Harvesting of leaves starts about 4 weeks after transplanting. Leaves may be cut once weekly during the vegetative phase until the crop loses its tenderness and leaves become stiff. When the crop starts developing inflorescences, it becomes more economical to replant. In some cases young plants are harvested whole with their roots attached, especially when grown under closer spacing. In Africa leaves of 15–30 cm long are preferred for marketing.
For seed production, plants should be harvested before fruits are fully ripe to reduce shattering of the seeds. Harvesting is usually done early in the morning. Plants are tied into bundles and dried in the sun for 4–10 days.

Yield The leaf yield of *Brassica juncea* ranges from 8–35 t/ha, with 20 t/ha as average on better farms. In Zimbabwe, this crop performs better during the winter, with average yields of 20–30 t/ha. Seed yields of brown mustard in India range from 900–1200 kg/ha with an oil content of 30–38% and in the United States seed yields are about 1100–1500 kg/ha.

Handling after harvest Under hot conditions, leaves wilt soon after harvest and are therefore sold as soon as possible. Where facilities are available, it is recommended that the product be cooled to near 0°C immediately after cutting, and that it be kept as cool as possible during transport and marketing. This can be done by placing ice between the leaves, which will also keep the humidity high. The humidity can also be kept high by packing the leaves in polythene bags or plastic film.
In Zimbabwe farmers dry the leaves in the sun for use during the off-season. Dried leaves offered as broken pieces and packed in polythene bags are frequently encountered at markets in Harare and elsewhere in Zimbabwe. Extraction of oil from the seed is by rotary mill, expeller or hydraulic processes. Mustard is made by mix-

ing ground seeds with water, spices and vinegar.

Genetic resources Large germplasm collections of *Brassica juncea* are maintained at the Australian Temperate Field Crops Collection, Horsham Victoria, Australia, the Institute of Crop Germplasm Resources (CAAS), Beijing, China, the All India Coordinated Research Project on Rape & Mustard, Haryana University, Hisar, Haryana, India and the N.I. Vavilov All-Russian Scientific Research Institute of Plant Industry, St Petersburg, Russian Federation. Smaller working collections are held in many other countries. A working collection of brown mustard with African landraces is present at the Horticultural Research Centre, Marondera, Zimbabwe. The diversity found in farmers' fields in Africa is considerable and there is a need to collect and evaluate this material before this potentially valuable resource disappears with the introduction of improved varieties.

Breeding Many African farmers use their own landraces of farm-saved seed. *Brassica juncea* can be reproduced by means of self-pollination, allowing for a rapid purification of new selections. East-West Seed Company in Thailand has developed cultivars especially for tropical conditions, e.g. 'Mayur' harvestable 30–35 days after sowing or 21–25 days after transplanting, and 'Laguna' with bolting tolerance at high temperatures and harvestable 40–45 days after sowing. 'Suehlihung No.2' is a cultivar from Taiwan that is resistant to soft rot and viruses. It can be grown year-round in Taiwan and be harvested 20 days after transplanting. The cultivar 'King Mustard' produces large and tender green-purple leaves.

Prospects There is a good potential for improving current landraces of this excellent vegetable which can be grown in humid hot lowland areas like the coastal regions of West Africa and the cooler regions of southern Africa. Many people prefer brown mustard and other loose-leaved *Brassica* types over white cabbage and when healthy seed of improved cultivars becomes available, the demand for this crop will increase. Prospects for *Brassica juncea* as an oil crop or for mustard production in tropical Africa are limited.

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Sources of illustration Toxopeus, H., 2001.

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BRASSICA NAPUS L.

Protologue Sp. pl. 2: 666 (1753).

Family Brassicaceae (Cruciferae)

Chromosome number $2n = 38$

Vernacular names

- Rape kale (En). Colza potager, colza fourrager (Fr).
- Swede, rutabaga (En). Rutabaga, chou-navet (Fr). Nabo amarelo, nabo de Suécia (Po).
- Oilseed rape, colza, canola (En). Colza (Fr). Colza (Po).

Origin and geographic distribution *Brassica napus* is an amphidiploid with one genome originating from *Brassica oleracea* L. ($2n = 18$) and the other from *Brassica rapa* L. ($2n = 20$). It is not known in the wild and probably originated in the eastern Mediterranean and West Asian region. It was introduced to western Europe where several types were developed.

Rape kale is a minor leafy vegetable in western Europe and a rather important fodder during

Brassica napus – planted

winter. It is of some importance in southern Africa, where it was introduced during colonial times. Swede (the thickened upper taproot and lower stem) is a minor vegetable in western Europe and in North America, on rare occasions found in southern Africa. In northern Mali and in oases in the Sahara an ancient introduction of swede is still grown. Fodder swede is occasionally grown in western Europe, but not recorded in tropical Africa. Oilseed rape was originally grown in India for its edible oil; later it became important as an industrial and lamp oil in Europe. Cultivars with a much improved quality edible oil have been developed from *Brassica napus*, *Brassica juncea* (L.) Czern. and *Brassica rapa* L. (collectively known as 'canola'), and these have become important oil crops in Europe, North America, China, Japan and India. Oilseed rape is also grown in the cooler highlands of Kenya and Tanzania, and reported as a minor oil crop from Ethiopia. Here and there, *Brassica napus* is found as an escape from cultivation, but less common than *Brassica rapa*.

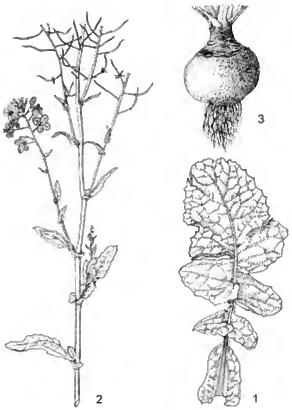
Uses The use of rape kale is similar to leaf cabbage cultivars (*Brassica oleracea* L.) such as 'sukuma wiki' in East Africa and Portuguese kale in southern Africa; its taste is somewhat more pungent. It is used as a vegetable dish or prepared into sauces accompanying the starchy staple food. In rural areas in Zimbabwe, rape kale leaves are dried for long-term preservation to provide vegetables during the dry season. In Europe young seedlings of *Brassica napus* are occasionally eaten in salads and used as garnish, replacing white mustard (*Sinapis alba* L.) and garden cress (*Lepidium sativum* L.). In Africa swede is rarely used as a root vegetable and only occasionally as a fodder crop. Oilseed rape is occasionally planted in East Africa for its edible oil, which is also used for soap making. The seeds are used to feed birds.

Production and international trade Rape kale and swede are only produced for the domestic market. No data on production or trade are available. *Brassica* oilseeds are the third most important source of vegetable oil after only soya bean and oil palm; specific information on production and trade of *Brassica napus* oil is not available.

Properties The nutritional composition of rape kale per 100 g edible portion (midribs removed, 87% of the product as purchased) is: water 88.2 g, energy 155 kJ (37 kcal), protein 3.8 g, fat 0.3 g, carbohydrate 4.8 g, Ca 250 mg, Mg 85 mg, P 81 mg, Fe 1.7 mg, carotene 1990 µg, thiamin 0.07 mg, riboflavin 0.06 mg, niacin 0.8 mg, ascorbic acid 55 mg. Compared to most other leafy vegetables, the content of micronutrients is high and the iron is in an easily digestible form. As all other members of *Brassica*, rape kale contains high levels of glucosinolates, which during the preparation form compounds with antioxidant and anticancer activities. The nutritional composition of swede per 100 g edible portion (thinly peeled, 73% of product as purchased) is: water 91 g, energy 100 kJ (24 kcal), protein 0.7 g, fat 0.3 g, carbohydrate 5.0 g, dietary fibre 2.4 g, Ca 26 mg, Mg 4 mg, P 11 mg, Fe 0.1 mg, Zn 0.1 g, carotene 350 µg, thiamin 0.15 mg, riboflavin trace, niacin 1.2 mg, folate 31 µg, ascorbic acid 31 mg (Holland, B., Unwin, I.D. & Buss, D.H., 1991). The oil of *Brassica napus* is similar to that of other *Brassica* species and is made up of erucic acid 25–55%, oleic acid 8–33%, linoleic acid 12–21%, linolenic acid 8–14%, eicosenoic acid 6–12%, palmitic acid 2–4%, stearic acid 0.8–1.5%, arachidic acid 0.5–1.2%, palmitoleic acid 0.2–0.5%, nervonic acid 0–2%, behenic acid 0–1% and lignoceric acid 0–1%. Eicosenoic acid and erucic acid are long-chain fatty acids that have antinutritional and toxic properties. Cultivars yielding oil low in eicosenoic acid and erucic acid have been developed. They are generally recognized as safe for human consumption. Together with cultivars of *Brassica juncea* and *Brassica rapa*, yielding similar oil, they are known as 'canola' in English and 'zéro-érucique' in French.

Adulterations and substitutes In dishes rape kale can be replaced by leaf cabbage (*Brassica oleracea*), brown mustard (*Brassica juncea*) or Ethiopian kale (*Brassica carinata* A.Braun). Swede is very similar to turnip (from *Brassica rapa*).

Description Erect, annual to biennial herb up to 1.5 m tall, with stout taproot, sometimes partly swollen (swede); stem branched. Leaves arranged spirally but in a rosette during the vegetative stage; stipules absent; lower leaves more or less petiolate, pinnately parted with 1–5 pairs of small lateral lobes and large terminal lobe up to 90 cm × 35 cm, crenate, toothed, sinuate or entire, glabrous or sparsely hairy, glaucous; stem leaves pinnately parted to simple, clasping at base, glabrous, glaucous. Inflorescence a terminal raceme up to 60 cm long, with buds overtopping the open flowers. Flowers bisexual, regular, 4-merous; pedicel up to 3 cm long, ascending; sepals 6–8 mm long, erect to slightly spreading, yellow-green; petals



Brassica napus – 1, basal stem leaf; 2, upper part of flowering and fruiting stem; 3, tuber of swede.
Redrawn and adapted by Iskak Syamsudin

obovate, 1–1.5 cm long, clawed, bright to dark yellow; stamens 6; ovary superior, cylindrical, 2-celled, stigma globose. Fruit a linear silique 4.5–11 cm × 3–4 mm, with a tapering beak 1–3 cm long, dehiscent, up to 30-seeded. Seeds globose, 1.5–2.5 mm in diameter, finely reticulate, bluish black to dark brown. Seedling with epigeal germination, with a taproot and lateral roots; hypocotyl c. 5 cm long, epicotyl 2–4 mm long; cotyledons with petiole c. 2 cm long, blade cordate, 1–1.5 cm long, cuneate at base, notched at apex.

Other botanical information *Brassica napus* is often difficult to distinguish from *Brassica rapa*. It differs in its basal leaves, which are usually less hairy and bluish green (bright green in *Brassica rapa*) and in its open flowers not over-topping the buds at the top of the inflorescence. The swede tuber can be distinguished from that of turnip (*Brassica rapa*) by its apex bearing a number of ridges, which are scars of leaf-bases. It is composed of the swollen upper part of the taproot (hypocotyl) and lower part of the stem, whereas the tuber of turnip is composed of the swollen upper part of the taproot (hypocotyl) only.

Brassica napus has been divided into 3 varieties: var. *napus* comprising the oil-seed crops, var. *pabularia* (DC.) Rchb. comprising rape kale and var. *napobrassica* (L.) Rchb. comprising swede. The plants cultivated in the Sahara, which have been distinguished as var. *sahariensis* Chev., belong to the latter variety, although it has also been suggested that they belong to *Brassica rapa*. A classification into cultivar-groups would be more appropriate.

Growth and development The seeds take 3–5 days to emerge at 20–25°C. First a rosette of leaves develops, in swede cultivars followed by thickening of the lower part of the stem and upper part of the root. *Brassica napus* is generally self-fertile, although insects improve seed setting.

Ecology Rape kale is a temperate climate vegetable and grows best under cool conditions. In southern Africa it grows best in the highlands and during the cool season with night temperatures of about 10°C and day temperatures of 15–20°C. It needs well-drained, fertile, neutral to slightly alkaline soils (pH 6.2–7.7) with a high organic matter content. Most swede cultivars are also adapted to temperate climates. The ecological requirements of the cultivars grown in the Sahara are not known. Those of oil-seed crops are similar to rape kale.

Propagation and planting Rape kale is grown exclusively by seed. The seedlings are raised in seedling trays or in a seedbed. The 1000-seed weight is about 5 g. If raised in a seedbed, about 500 g of seed is enough for 1 ha. The seedbed should be well drained and have a fine tilth, and should not have been planted with a *Brassica* crop for at least three years. The seed should be buried no more than 5 mm below the ground and is drilled in rows 10–15 cm apart. A basal dressing, e.g. with NPK fertilizer 5–18–20 at a rate of 100 g/m^2, helps to hasten seedling development. Under optimum conditions seedlings are ready for transplanting in 4 weeks. When seedling trays are used, care should be taken to ensure that the seedlings receive adequate nutrition, especially phosphorus, to avoid retarded growth. In the field, plants are spaced at 75–100 cm between rows and 45–60 cm within the row.
For oil production rape is always direct seeded at a seed rate of 5–9 kg/ha, aiming at a density of 160,000 plants/ha.

Management Weed control is very important during early establishment. Two rounds of weeding are usually required. If rainfall is insufficient, the crop should be irrigated regu-

larly. Since the leaves are continuously harvested, the uptake of minerals is high, and inorganic fertilizers should be applied, e.g. 700–800 kg/ha NPK 5–18–10 before planting. Side dressing of N helps to keep the crop in the vegetative state allowing more leaves to develop. A gift of 100 kg/ha urea, applied after a harvest, assures high yields.
For an oilseed rape crop yielding 2 t seed, application of N 40–50 kg/ha, P 50–60 kg/ha and K 25–30 kg/ha before planting and a topdressing of N 40–50 kg/ha is generally recommended. Seed set and consequently yields are often improved by placing beehives near flowering rape seed fields.

Diseases and pests Seedlings are very susceptible to damping off caused by *Rhizoctonia* and *Fusarium*. A protectant fungicide may be applied as a seed-dressing or as a drench. Black rot (*Xanthomonas campestris*) and soft rot (*Erwinia carotovora*) are important diseases, *Fusarium* yellows sometimes cause problems. At the seedling stage, cut worms (*Agrotis* spp.) are a major pest. As the crop develops further, aphids may become a major problem and so is diamondback moth (*Plutella xylostella*), web worm (*Hellula undalis*) and bagrada bug (*Bagrada hilaris*).

Harvesting Harvesting starts 4 weeks after planting under favourable conditions and can last for 3 months. Leaves are harvested when they have attained a size that is acceptable at the market. Swede can be harvested usually 90 days after sowing; oilseed rape after 75–100 days.

Yields Yields of rape kale of 25–50 t/ha (fresh weight) can be expected. In Zimbabwe yields of up to 75 t/ha have been achieved. Yields of swede in Europe may attain 50–80 t/ha. World average seed yield of oilseed rape is 1400 kg/ha. Smallholders in India or China harvest only 500–800 kg/ha, large farms in Canada or Australia 900–1600 kg/ha, whereas yields in Europe are 2000–4000 kg/ha.

Handling after harvest Leaves are harvested individually and then tied together into bundles that vary in size depending on whether they are coming from the farm or from the wholesale market. Harvesting usually takes place just before dusk or at dawn and the harvested leaves are taken to the market straight away. As the leaves are very perishable, traders regularly sprinkle them with cold water to keep them fresh. Most oilseed rape is processed in large factories, where the oil is extracted by screw press or by solvent and then refined. Colza oil is light-coloured and bland-tasting.

Genetic resources Germplasm collections of *Brassica napus* are maintained in several European genebanks.

Breeding Western seed companies have made little effort to genetically improve rape kale or swede. Japanese seed companies have created new amphidiploid *Brassica napus* types by crossing *Brassica oleracea* and *Brassica rapa*. By crossings of heat tolerant cultivars of white headed cabbage and Chinese cabbage, new types of heading *Brassica napus* for the tropics might be developed, combining the strength of white headed cabbage with the finer taste of Chinese cabbage, and disease resistances of both parental species. In southern Africa farmers use farm-saved seed of rape kale from introductions that were made a long time ago. Selections from these local cultivars are now being made by East-West Seed Company in Zimbabwe. In oilseed rape open-pollinated cultivars are now being replaced by higher yielding F_1 hybrids.

Prospects Rape kale has an excellent nutritional composition and taste, but due to the high perishability in comparison with leaf cabbage, and also to its low adaptability to tropical conditions, it will remain of minor importance as a leafy vegetable in tropical Africa, unless systematic efforts are made to breed cultivars more adapted to tropical conditions. Swede is also likely to remain of local importance only. If adapted cultivars are developed oilseed rape may become a more important oil-seed crop for the African highlands.

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Authors H. Toxopeus & B. Mvere

BRASSICA OLERACEA L. (leaf cabbage)

Protologue Sp. pl. 2: 667 (1753).
Family Brassicaceae (Cruciferae)
Chromosome number $2n = 18$

Vernacular names Leaf cabbage, kale, collard, Tronchuda cabbage (En). Chou vert, chou

vert non pommé, chou cavalier, chou à grosses côtes (Fr). Couve galega, couve tronchuda (Po). Sukuma wiki (Sw).

Origin and geographic distribution *Brassica oleracea* was domesticated about 5000 years ago and is now cultivated throughout the world, although in the tropics it is mostly restricted to higher elevations. Leaf cabbage comprises diverse cultigens developed from wild *Brassica oleracea*, which has a northern Mediterranean and western European origin. It is probably the first cabbage crop cultivated. Types with tall plants grown for repeated leaf pickings are popular everywhere in East and southern Africa, but less common in Central Africa and rare in West Africa. Leaf cabbage is the most important leafy vegetable in the highlands of Kenya and surrounding countries, and is known as 'sukuma wiki'. In Zimbabwe the most important types are called 'rugare', 'viscose' and 'tronchuda'. There are numerous cultivars and clones of leaf cabbage. Apart from the widely distributed Portuguese kale and marrow-stem kale, Western leaf cabbage types such as curly kale or borecole are rarely found in tropical Africa, and this is also the case for Chinese kale.

Uses Leaf cabbage is grown for the consumption of the fresh leaves, mostly after removal of the thick midribs and petioles. The leaves are used as a vegetable dish or prepared into sauces. Young shoots and tips with young inflorescences are occasionally used for these purposes. Traditional preparation involves boiling of shredded leaves in water to which salt and other ingredients such as onions, tomatoes, garlic, hot peppers, peanuts or sesame are added. In Zimbabwe people occasionally dry leaf cabbage leaves for long-term conservation.

In Portugal the leaves are used for the preparation of a traditional dish 'caldo verde', a thick dark green soup. This dish is also known in Angola and Mozambique. Processing by canning and freezing are practised in Western countries. Marrow-stem kale and special leaf cabbage cultivars are used as fodder crops. The medicinal properties of cabbage crops are highly esteemed in Western countries, but as far as known not in Africa. The leaves are often consumed because they are believed to be anticarcinogenic, and they are used to treat gout and rheumatism, whereas the seeds are considered diuretic, laxative, stomachic and anthelmintic.

Production and international trade Leaf cabbage is among the most important leafy vegetables in East and southern Africa, grown year-round for the domestic market. The total area planted may amount to over 100,000 ha, but no precise data are known. A conservative estimation for the area planted with leaf cabbage in Zimbabwe is 2500 ha for commercial crops and 2500 ha for subsistence crops, as most rural households grow leaf cabbage for family use.

Properties Variation in nutritive composition between the various types of leaf cabbage is considerable and the nutritional composition given here is only indicative. Raw leaves contain per 100 g edible portion: water 84.5 g, energy 209 kJ (50 kcal), protein 3.3 g, fat 0.7 g, carbohydrate 10.0 g, total dietary fibre 2.0 g, Ca 135 mg, P 56 mg, Fe 1.7 mg, Mg 34 mg, Zn 0.44 mg, vitamin A 15,376 IU, thiamin 0.11 mg, riboflavin 0.13 mg, niacin 1.0 mg, folate 29 µg, ascorbic acid 120 mg (USDA, 2003). Compared to most other leafy vegetables, the content of micronutrients is remarkably high and the iron is in an easily digestible form. As all other members of *Brassica*, leaf cabbage contains high levels of glucosinolates, which during preparation form compounds with antioxidant and anticancer activities. In experiments some of these compounds inhibited cancer growth, some blocked cancer-causing compounds and others prevented the formation of carcinogens. The major glucosinolates in Portuguese kale are sinigrin (2-propenyl-glucosinolate), glucoiberin (3-methylsulphinyl-propyl-glucosinolate) and glucobrassicin (indol-3-yl-glucosinolate).

Adulterations and substitutions Leaf cabbage in dishes may be replaced by leaves of some other *Brassica* species, e.g. brown mustard (*Brassica juncea* (L.) Czern.), rape kale (*Brassica napus* L.) and Ethiopian kale (*Brassica carinata* A.Braun).

Description Erect, glabrous, annual to perennial herb up to 3 m tall; stem often woody at base, sometimes thickened, with ascending branches; root system strongly branched. Leaves alternate, fleshy, more or less coated with a layer of wax, with whitish veins; stipules absent; lower leaves petiolate, pinnately parted with 1–5 pairs of small lateral lobes and large terminal lobe up to 50 cm × 30 cm, cordate at base, rounded at apex, entire to undulate, crispy or toothed; stem leaves oblong or obovate to almost linear, clasping or auriculate at base. Inflorescence a terminal paniculate raceme up to 100 cm long. Flowers bisexual, regular, 4-merous; pedicel up to 2 cm long, as-

Brassica oleracea (leaf cabbage) – 1, leafy shoot; 2, flowering and fruiting branch; 3, flower. Drawn from life plant by R.H.M.J. Lemmens

cending; sepals oblong, c. 1 cm long, erect; petals obovate, 1.5–2.5 cm long, clawed, pale to bright yellow or whitish; stamens 6; ovary superior, cylindrical, 2-celled, stigma globose. Fruit a linear silique 5–10 cm × c. 5 mm, with a tapering beak 5–15 mm long, dehiscent, up to 30-seeded. Seeds globose, 1.5–2 mm in diameter, finely reticulate, dark brown. Seedling with epigeal germination, with a taproot and lateral roots; hypocotyl 3–5 cm long, epicotyl absent; cotyledons with petiole 1–2 cm long, blade cordate, 1–1.5 cm long, cuneate at base, notched at apex.

Other botanical information Leaf cabbage is among the cultivated *Brassica oleracea* types most closely related to wild cabbage. It comprises many different types, which have been classified in convar. *acephala* (DC.) Alef. (var. *medullosa* Thell. for marrow-stem kale, var. *palmifolia* DC. for palmtree kale, var. *sabellica* L. for curly kale and var. *viridis* L. for collard), convar. *botrytis* (L.) Alef. (var. *alboglabra* (L.H.Bailey) Musil for Chinese kale), convar. *costata* (DC.) Gladis (Portuguese kale) and convar. *fruticosa* (Metzg.) Alef. (var. *ramosa* DC. for thousand-headed kale). These types can best be considered as cultivar-groups and as such have been called Marrowstem Kale Group, Palmtree Kale Group, Curly Kale Group, Collard Group, Chinese Kale Group, Portuguese Kale Group and Thousand-headed Kale Group, respectively.

A practical classification used in Zimbabwe (with types listed in order of decreasing importance for the domestic market) is:

Rugare: vegetatively propagated, rarely by seed (flowers only at high altitudes and after some degree of vernalization); plants 2–3 m tall, for repeated leaf pickings, white flowering; many small shoots developing at the base and lower internodes (hence also called thousand-headed cabbage); long life and harvest season; pale blue-green and somewhat curly leaves, but clones available with different leaf colour.

Viscose: a selection from 'rugare' that has gained popularity for commercial production with repeated leaf pickings because of its improved hardiness in the field; vegetatively propagated, rarely by seed (segregates into different types); leaves darker green and more pronouncedly curled than 'rugare', some clones in between 'rugare' and 'viscose'.

Chou moellier: propagated by seed; marrow-stem type, plants comparatively short with short internodes and very thick stems, with large, dark green, somewhat curly leaves, for repeated leaf pickings or once-over harvest; rarely flowering in Zimbabwe; seed imported from Western countries.

Covo or couve galega: propagated by seed; similar to Portuguese kale, tall plants with long internodes, for repeated leaf pickings, white flowering, shorter than 'rugare' and harvest season also shorter; leaves blue-green; mostly grown from seed imported from Europe, but sometimes from local seed production; local cultivars heterogeneous, sometimes close to 'rugare' and 'viscose', readily bolting, plants from imported seed reluctant to bolt.

Couve tronchuda: propagated by seed; plant habit half-heading, compact, for single once-over harvest; seed imported from Europe; popular in Mozambique.

Sukuma wiki: mostly propagated by seed, sometimes vegetatively; plant habit close to 'rugare'; for repeated leaf pickings, yellow flowering; rare in Zimbabwe, but the most common type in East African countries; heterogeneous, often from local seed.

Growth and development Leaf cabbage is grown from seed or stem cuttings. Young plants grown from seed develop a strong taproot with lateral roots, whereas rooting shoots

develop several strong lateral roots. Depending on the desired leaf tenderness and size, the first leaves can be picked in 4–6 weeks from planting. Removal of older leaves promotes development of new ones and therefore a high leaf yield. Leaf production stops when plants start to flower, or when the crop becomes too old and the stem rots. Flowering is controlled by temperature. Local seed-propagated cultivars bolt easily when grown above 500 m altitude. Vegetatively propagated types do not flower easily and grow indeterminately if flowering is not induced by growing them at high altitudes or by artificial vernalization. European cultivars from imported seed usually do not flower at low altitudes; they require vernalization with some weeks below 10°C. Regular leaf pickings and high nitrogen fertilizing retard bolting. Flowers are insect-pollinated, mainly by bees. The fruit reaches its maximum length 3–4 weeks after anthesis. For a seed crop, continuous leaf harvesting is discouraged to ensure that healthy, viable seed is produced. Leaf cabbage flowers during 1–2 months, then the plants senesce and die. Seed crops should be well isolated (1000 m) from other flowering *Brassica oleracea* plants because of the strong outcrossing character.

Ecology Leaf cabbage grows best under full sunlight. The optimum temperature for growth is 15–25°C, but there are great differences in cold or heat tolerance between cultivars. Leaf cabbage tolerates low temperatures, European types even tolerate frost. A regular supply of water is essential for good growth, either by rain or irrigation (about 5 mm per day). Soils should be well drained and fertile, having good moisture retaining capacity, high organic matter content and pH > 6.0. On acid soils leaf cabbage is often heavily affected by club root.

Propagation and planting The 1000-seed weight of leaf cabbage is 2–4 g. Dry seed (6% water) remains viable for at least 4 years when stored below 20°C. Freshly harvested seed may show poor germination, which is overcome by soaking in water overnight. After storage for 3–4 months dormancy disappears. Seeds germinate within 3–6 days at 15–20°C. Chilling the seed for 3 days prior to planting may speed up germination. A fine tilth is essential for good germination and emergence. Direct seeding and transplanting are feasible options but the former requires more seed. Seeds are usually sown on a seedbed. Young seedlings may require light shading. About 300–500 g seed and 200 m² of seedbed are required to plant 1 ha. Seedlings are ready for transplanting 4–6 weeks after sowing.

Vegetative propagation is much applied, especially for African types that produce few or no seed. Shoots are usually planted directly, but it is also possible to plant them first in a nursery bed for rooting. The disadvantage of vegetative propagation is an uneven stand caused by planting material being of variable size, and high plant losses due to rotting and wilting diseases. Plant spacings of 20–30 cm between plants in the row and 50–80 cm between rows is used, depending on the size of the cultivar.

Management Crop management is similar to that for headed cabbage. Rotation with crops other than *Brassicaceae* is recommended. The uptake of minerals is extremely high. Soil preparation includes deep ploughing with incorporation of up to 30 t/ha organic manure. Before planting fertilizer is applied, e.g. NPK 15–15–15 at a rate of 500 kg/ha, followed by a top dressing of N fertilizer for good vegetative growth. Planting on ridges during the wet season to improve drainage is recommended. The crop should be kept free of weeds, especially in the first month after transplanting.

Diseases and pests Diseases and pests of leaf cabbage are essentially the same as for the better studied headed cabbage, but in general leaf cabbage is more resistant. Grey leaf mould (*Alternaria brassicae*) and downy mildew (*Peronospora parasitica*) can be controlled by fungicides; bacterial soft rot (*Erwinia carotovora*) occurs under hot and humid conditions; black rot (*Xanthomonas campestris* pv. *campestris*) is controlled by disease-free seeds and avoidance of overhead irrigation. Club root (*Plasmodiophora brassicae*) has been spreading fast during the last decades and has become the most detrimental disease in many highland areas. Tolerance to it differs between clones and cultivars. Club root is controlled by crop rotation, liming and cultivation on soils with pH > 6.5. Other diseases are ringspot (*Mycosphaerella brassicicola*), cabbage yellows (*Fusarium oxysporum*) to be controlled by crop rotation, and turnip mosaic virus, which can be prevented by control of the aphid vectors. Blackleg (*Leptosphaeria maculans*) can be controlled by chemicals or planting resistant cultivars. In Portuguese kale resistance was found against *Peronospora parasitica*, *Xanthomonas campestris* pv. *campestris*, *Plasmodiophora brassicae* and *Leptosphaeria maculans*.

Important pests include diamondback moth (*Plutella xylostella*), for which chemical control

is increasingly ineffective because of the quick build-up of resistance to all except neem-based insecticides. In headed cabbage good results were obtained with biological control by sex pheromones and parasitoids, and this is probably effective also in leaf cabbage. Other insect pests are leaf webber (*Crocidolomia binotalis*) and web worm (*Hellula undalis*) particularly in southern Africa. Occasional pests are cut worm (*Spodoptera littoralis*), flea beetle (*Phyllotreta* spp.), cabbage butterfly (*Pieris* spp.) and cabbage aphid (*Brevicoryne brassicae*).

Harvesting Leaves are harvested when needed at any stage, depending on consumer preference and intended use. Leaf harvesting continues until flowering when leaf productivity goes down.

Yield Data on yield are scarce. Average yields are around 20 t/ha from a once-over harvest. An estimated total yield of up to 50 t/ha from about 10 repeated leaf pickings in 6 months can be obtained. A seed crop may yield 1–2 t seed per ha.

Handling after harvest Leaf cabbage is more perishable than headed cabbage because the leaves are open and have a large surface to volume ratio. However, the leaves are less perishable than those of Ethiopian kale (*Brassica carinata*), brown mustard (*Brassica juncea*) and rape kale (*Brassica napus*) because of their more waxy surface.

Leaves to be sold on the market should be harvested in the evening or early morning and immediately taken to the market. In Zimbabwe, traders sprinkle cold water onto the leaves or suspend the stalks in water to maintain freshness. The sweetness of leaves that have been harvested in warm weather can be improved by keeping them in a refrigerator for a couple of days before cooking. Locally, the fresh leaves are sun-dried for long-term storage.

Genetic resources Collections of leaf cabbage are held in European countries, notably in Portugal (Banco Português de Germoplasma Vegetal (BPGV), S. Pedro de Merelim, Braga) and the Netherlands (Centre for Genetic Resources, Wageningen), and in the United States (Northeast Regional Plant Introduction Station, PGRU, USDA-ARS, Cornell University, Geneva NY) and Russia (N.I. Vavilov All-Russian Scientific Research Institute of Plant Industry, St Petersburg). Leaf cabbage is a main source of genes for conferring resistance to environmental stress to other *Brassica oleracea* types. Traditional leaf cabbage clones and cultivars have developed desirable characters including tolerance to diseases, pests and environmental stress. Collection and conservation of this germplasm is urgently needed, because the expected increasing popularity of improved cultivars will cause genetic erosion.

Breeding Several international seed companies have created improved cultivars of the European leaf cabbage types including Portuguese kale, which are sold in seed shops everywhere in East and southern Africa. Commercial seed from a local cultivar of 'sukuma wiki' is available in seed shops in Kenya. However, breeding efforts on local leaf cabbage types in Africa are almost absent. Imported cultivars can be outstanding in yield and uniformity, but they lack resistance to pests and diseases as found in the local cultivars, are less suited to the consumer taste and are not suitable for cultivation at lower altitudes. In Zimbabwe, East West Seed Company recently started breeding work on local cultivars. It was observed that seed-propagated crops from plants that are normally vegetatively propagated show earlier flowering in the following generation, implying a less desirable selection for early bolting. They also showed a wide variation, showing the highly heterogenic nature of leaf cabbage.

Prospects Leaf cabbage is an extremely important leaf vegetable in East and southern Africa, in many regions at least as important as headed cabbage. The high yield capacity, popularity among consumers and excellent nutritional properties all indicate the need for more breeding and research work on cultural practices including integrated control of pests and diseases. There is especially a great need for healthy seed of improved and adapted cultivars.

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Authors B. Mvere & M. van der Werff

BRASSICA OLERACEA L. (headed cabbage)

Protologue Sp. pl. 2: 667 (1753).
Family Brassicaceae (Cruciferae)
Chromosome number $2n = 18$

Vernacular names Headed cabbage, cabbage (En). Chou pommé, chou cabus (Fr). Couve repolho (Po). Kabichi, kabichu (Sw).

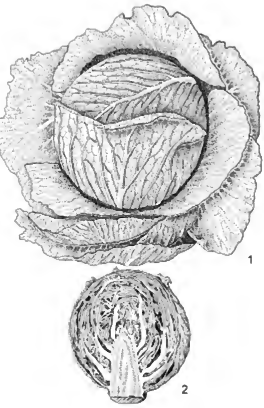
Origin and geographic distribution Headed cabbage evolved in north-western Europe during the early Middle Ages from leafy unbranched and thin-stemmed kales, which were introduced in Roman times from the Mediterranean area, where *Brassica oleracea* and related species occur naturally in coastal areas. Wild types of *Brassica oleracea* growing along the coasts of western Europe may have contributed to the development. Whereas the primitive types were originally cultivated for medicinal purposes, headed cabbage had become one of the most important vegetables in 16th century Europe. From then onwards headed cabbage was introduced worldwide. In tropical and subtropical areas commercial cultivation is still mostly restricted to the cooler climates of the highlands or to the mild cool seasons at higher latitudes. In Africa headed cabbage is especially common in East Africa and Egypt.

Uses Headed cabbage is usually consumed as a cooked or stir-fried vegetable, sometimes pickled. It is also eaten fresh as an ingredient of coleslaw (a salad made of raw sliced or chopped cabbage) and mixed salads. It may be preserved by steaming and drying or by anaerobic fermentation in brine (sauerkraut).

Production and international trade The importance of headed cabbage in tropical and subtropical regions, mainly early maturing white headed cabbage with firm and round to flat heads (1–2.5 kg), has increased considerably during recent decades. It can be fairly easily produced in large quantities, transported over great distances without much damage and stored for a few weeks. The area planted with headed cabbage worldwide in 2002 was estimated at about 3 million ha in 124 countries (producing some 62.5 million t): 2 million ha in Asia (of which 1.5 million ha in China), 0.5 million ha in Europe, 180,000 ha in the Americas, and an estimated 100,000 ha in Africa. Reliable data on areas planted annually with headed cabbage are lacking for most countries in tropical Africa. Based on sales of commercial seed, at least 40,000 ha of white headed cabbage is grown in Kenya, Uganda and Tanzania together, 10,000 ha in the region covering Malawi, Zambia and Zimbabwe, 4000 ha in Ethiopia and 3000 ha in Cameroon. Almost all white headed cabbage is produced for local urban markets. Mozambique imports considerable quantities of headed cabbage from South Africa and until recently did so also from Zimbabwe.

Properties The nutritional composition of white headed cabbage per 100 g edible portion (i.e. 77% of the product as purchased) is: water 90.1 g, energy 109 kJ (26 kcal), protein 1.7 g, fat 0.4 g, carbohydrate 4.1 g, dietary fibre 2.9 g, Ca 52 mg, Mg 8 mg, P 41 mg, Fe 0.7 mg, Zn 0.3 mg, carotene 385 µg, thiamin 0.15 mg, riboflavin 0.02 mg, niacin 0.5 mg, folate 75 µg, ascorbic acid 49 mg (Holland, B., Unwin, I.D. & Buss, D.H., 1991).
All *Brassica* crops contain glucosinolates, which in crushed leaves are hydrolyzed by the enzyme myrosinase to mostly bitter-tasting thiocyanates and volatile isothiocyanates; these compounds have antimicrobial and anticarcinogenic properties. In headed cabbage glucosinolate content is rather low (100 mg per 100 g) as a result of centuries of selection against bitter-tasting plants. In spite of its ancestry, headed cabbage does not seem to have medicinal applications.

Description Erect, glabrous, biennial herb up to 60 cm tall at the mature vegetative stage, up to 200 cm when flowering, with unbranched stem up to 30 cm long, gradually thickening upwards; root system strongly branched. Leaves alternate but closely arranged, sessile, basal leaves forming a rosette, upper leaves in a compact flattened globose to ellipsoid head up to 30 cm in diameter, usually simple; stipules absent; blade ovate to obovate or almost circular, up to 35 cm × 30 cm, undulate or irregularly incised to almost entire, coated with a layer of wax, whitish to pale green with whitish veins (white headed cabbage), red-purple (red headed cabbage), or green to yellow-green and puckered (savoy headed cabbage). Inflorescence a terminal paniculate raceme up to 100 cm long. Flowers bisexual, regular, 4-merous; pedicel up to 2 cm long, ascending; sepals oblong, c. 1 cm long, erect; petals obovate, 1.5–2.5 cm long, clawed, pale to bright yellow or whitish; stamens 6; ovary superior, cylindrical, 2-celled, stigma globose. Fruit a linear silique 5–10 cm × c. 5 mm, with a tapering beak 5–15 mm long, dehiscent, up to 30-seeded. Seeds globose, 2–4 mm in diameter, finely reticulate, brown. Seedling with epigeal germination, with a taproot and lateral roots; hypocotyl 3–5 cm



Brassica oleracea (headed cabbage) – 1, plant habit; 2, head in longitudinal section.
Source: PROSEA

long, epicotyl absent; cotyledons with petiole 1–2 cm long, blade cordate, 1–1.5 cm long, cuneate at base, notched at apex.

Other botanical information Headed cabbage has been classified as convar. *capitata* (L.) Alef., which has been subdivided in var. *capitata* L. comprising white headed cabbage (with smooth white to green leaves) and red headed cabbage (with red leaves), and var. *sabauda* L. comprising savoy headed cabbage (with curly green leaves). These 3 types of headed cabbage can best be considered as cultivar-groups and as such have been called White Headed Cabbage Group, Red Headed Cabbage Group and Savoy Headed Cabbage Group. However, a formal distinction into these groups at world level is often considered superfluous and confusing, although at a local level it may be relevant.

Hundreds of cultivars of headed cabbage are grown worldwide. In the market gardens of tropical regions early-maturing compact and round- or flat-headed F_1 hybrids of white headed cabbage are increasingly replacing the open-pollinated cultivars such as 'Golden Acre', 'Copenhagen Market', 'Glory of Enkhuizen', the flat-headed 'Drumhead' and the pointed 'Sugarloaf'. Examples of F_1 hybrid cultivars are 'Fresco', 'Gloria' (= 'Green Boy'), 'Green Coronet', 'KK Cross', 'KY Cross' and 'Hercules'. White headed cabbage hybrids of Japanese and Taiwanese origin in particular often are early maturing and have heat tolerance. Technisem markets several cultivars suitable for tropical lowland areas (e.g. coastal areas near Dakar and Abidjan) including 'KK Cross', 'Fabula', 'Rustica' and 'Sahel', which can be harvested 60–80 days after planting, and the very early (45–55 days) but smaller-headed 'Quick Start' and 'Bali'. All these cultivars are *Xanthomonas* resistant; 'Fabula', 'Rustica' and 'Sahel' are *Fusarium* resistant too.

Red headed cabbage and savoy headed cabbage are of economic importance mainly in Europe and America, but not common in tropical regions. Examples of Taiwanese cultivars of red cabbage are 'Scarlet' and 'Sunny Side'. The Technisem red headed cabbage cultivar 'Red Ball' is heat and *Xanthomonas* tolerant.

Growth and development Seeds germinate within 3–6 days and seedlings have 4 true leaves 4–5 weeks after sowing at 15–20°C average daily temperatures. The first 7–15 leaves expand and unfold to form a rosette, commonly called the frame. Subsequent leaves only partly unfold, forming the shell of the head; the growing point increases in size, the stem thickens and the head is filled out with fleshy leaves. The head is solid and ready for harvesting 80–120 days after germination, depending on genotype and climate.

Most headed cabbage types require 6–8 weeks exposure to temperatures below 10°C for flower initiation and bolting. The main stem increases in length rapidly, causing the head to burst, and then develops a branched inflorescence. Flowering starts at the base of the inflorescence, 2–3 months after the first sign of bolting and continues for 4–5 weeks. Sporophytic self-incompatibility (1-locus system with multiple alleles) precludes natural self-fertilization. Insects, especially bees, effect cross-pollination. Seeds are mature 8–10 weeks after anthesis.

Ecology Headed cabbage grows best at average daily temperatures of 15–20°C and a diurnal variation of at least 5°C. In tropical regions these conditions are only met in highlands above 800 m. At temperatures in excess of 25°C young plants still grow well, but subsequent head formation will be retarded. Some Japanese and Taiwanese F_1 hybrids are more

heat-tolerant, but even these do not perform so well under lowland tropical conditions.

Most headed cabbage cultivars are daylength neutral and flower initiation is mainly induced by low temperatures. Half-grown plants can even withstand short spells of frost (–5°C).

Soils should be well drained and fertile, having good moisture retaining capacity, high organic matter content and a pH of 6.5–7.5. Because of its shallow root system, headed cabbage needs a regular supply of water throughout the growing season either by rain or irrigation. Evapotranspiration of a fully-grown headed cabbage field can reach 4 mm per day.

Propagation and planting Dry headed cabbage seed (6% moisture content) will remain viable for at least 4–6 years when stored dry at temperatures below 18°C. Freshly harvested seed sometimes gives poor germination. Soaking overnight and rinsing with water overcomes this. After 3–4 months storage dormancy disappears. Seeds are sown on seedbeds, in pots or in trays; young seedlings may require protection from excessive sunshine by light shading. About 300–500 g seed and about 200 m^2 of seedbed are required for 1 ha of cabbage. The 1000-seed weight is 3–5 g. Transplanting to the field takes place 4–5 weeks later, when the seedlings have 4–6 true leaves. Plant densities of 30,000–50,000 plants per ha are usually applied and spacing is 40–50 cm × 55–60 cm. Head size can be regulated to some extent by adjusting plant density.

Lateral shoots from decapitated stumps can be rooted and transplanted. This method of vegetative propagation is practised in breeding programmes to maintain selected plants.

Management Headed cabbage is often grown in rotation with maize, rice, potato, legumes, tobacco and vegetables (tomato, capsicum pepper, onion, carrot). Soil preparation includes deep digging, mixing with compost or stable manure (20–50 t/ha), followed by fine tillage. Before planting NPK fertilizer is applied and for good vegetative growth a top dressing with N fertilizer is given when head formation starts. Type of fertilizer and quantities depend on soil type, initial nutrient reserves in the soil and yield level. The uptake and removal of nutrients is high. A headed cabbage crop with a yield of 25 t/ha absorbs approximately 100 kg N, 12 kg P and 75 kg K. At least double that quantity is recommended as fertilizer gift. Growing headed cabbage on ridges during the wet season improves drainage. The crop should be kept free of weeds, especially in the first month after transplanting. Mulching (dry grass or straw) is beneficial to growth.

Diseases and pests The most important diseases in tropical areas are: downy mildew (*Peronospora parasitica*) important mainly at elevations above 1200 m, and grey leaf mould (*Alternaria brassicae*), both of which can be controlled by fungicides and selection of tolerant cultivars; bacterial soft rot (*Erwinia carotovora*) under hot and humid conditions; black rot (*Xanthomonas campestris* pv. *campestris*), controlled by disease-free seeds and seedlings (some cultivars have a good level of tolerance) and avoidance of overhead irrigation; wire stem (*Rhizoctonia solani*), inducing damping off and vein and leaf necrosis below the head; club root (*Plasmodiophora brassicae*) a serious threat also at medium elevations (about 700 m), prevented by wide crop rotation, eradication of cruciferous weeds (alternative hosts of the pathogen), by liming and cultivation on soils with pH >7, and by stimulating antagonistic fungi in the soil (such as *Trichoderma* and *Mortierella* spp.). Club root has been spreading fast during the last decades and has become the most detrimental disease in many highland areas. A few cultivars appear to have some tolerance, but high levels of durable resistance to club root are not yet available. Other diseases are: ringspot (*Mycosphaerella brassicicola*); cabbage yellows (*Fusarium oxysporum* f.sp. *conglutinans*), to be controlled by crop rotation and resistant cultivars; cauliflower and turnip mosaic virus, which can be prevented by control of the aphid vectors and by eradicating hosts like wild mustard. Alum dusted on stumps has been found effective in controlling storage rots caused by *Erwinia*.

Important pests include: diamondback moth (*Plutella xylostella*) for which chemical control is increasingly ineffective because of the quick build-up of resistance to all except neem-based insecticides, whereas biological control with sex pheromones and parasitoids (*Diadegma semiclausum*, *Apanteles plutellae*, *Diadromus collaris* and *Oomyzus sokolowski*) is promising; leaf webber (*Crocidolomia binotalis*); web worm (*Hellula undalis*) particularly in southern Africa. Occasional pests are cut worm (*Spodoptera littoralis*), flea beetle (*Phyllotreta* spp.), cabbage butterfly (*Pieris* spp.) and cabbage aphid (*Brevicoryne brassicae*). Indian mustard (*Brassica juncea* (L.) Czern.) may be used as a trap crop for diamondback moth and other pests when planted in rows between

headed cabbage; chemical control can then be restricted to the mustard plants. Tomato and onions are good repellent crops for the diamondback moth.

Harvesting Well filled-out and solid heads are cut, usually with a few wrapper leaves attached, 2–3 months after transplanting. The period of harvesting is 1–2 weeks, F_1 hybrids maturing more uniformly than open-pollinated cultivars. The lateral shoots developing on decapitated stumps are sometimes harvested as a sort of loose-leaved mini cabbage.

Yield Open-pollinated cultivars yield 10–25 t/ha. F_1 hybrids 40–60 t/ha under optimum growing conditions. In tropical regions yields are generally highest above 800 m altitude. Seed yields are 200–1000 kg/ha in temperate climates.

Handling after harvest Cabbage heads can be stored for 7–10 days in a cool (20°C), well-aerated and dark space. Transportation should be in ventilated boxes, net bags or lightweight Hessian sacks. At 1°C and high relative humidity (95–98%) cabbage heads can be kept for 2–3 months.

Genetic resources Working and germplasm collections of white cabbage and other *Brassica* crops are available in several research centres in Europe, Russian Federation, United States, India and Japan. In Europe a *Brassica* genebank has been established in cooperation with private companies. A central electronic catalogue of the collections is available at the Centre for Genetic Resources (CGN), Wageningen, Netherlands. Preservation of germplasm from the centres of genetic diversity (Mediterranean region) appears adequate and interspecific crosses within the *Brassicaceae* family widens the genepool available to breeders.

Breeding Present breeding programmes aim at F_1 hybrids based on single crosses between inbred lines. Inbreeding is usually effected by manual bud-pollination or treatment with CO_2 (2–10%) after bee pollination to temporarily break the self-incompatibility. Fully homozygous lines are now produced much faster from doubled haploids through microspore culture, a technique perfected for *Brassica oleracea* in the early 1990s.

Main breeding objectives include: head shape and size, internal firmness, leaf configuration and colour, core (= internal stem) length, taste, vitamin C content, earliness, standing ability (delayed splitting of the head at maturity), productivity, heat tolerance, resistance to diseases, pests and tip burn (physiological disorder). F_1 hybrid cultivars with good host resistance to cabbage yellows, black rot and downy mildew have been developed. However, efforts to breed for durable resistance to club root have had limited success so far, due to the large genetic variability of the pathogen, the limited sources of resistance and the complex inheritance of host resistance. Headed cabbage cultivars with proven resistance in one region are frequently susceptible elsewhere due to the presence of different pathotypes of *Plasmodiophora brassicae*.

Commercial seed production of F_1 hybrids, which was traditionally based on the system of self-incompatibility, is increasingly realized with cytoplasmic male sterility (CMS) in the female lines. The negative effects initially linked to the 'Ogura' system of CMS in *Brassica oleracea*, such as leaf chlorosis at low temperatures, low female fertility and poor insect pollination due to absence of nectar glands in the flowers, have been overcome (e.g. by hybridization with protoplasts, followed by strict selection among regenerated plants).

Prospects The importance of white headed cabbage will further increase in tropical regions. Heat-tolerant cultivars enable cultivation at lower elevations, but market gardening will continue to prevail in the highlands because of higher yield potential, better head quality and fewer disease and pest problems. Considerable progress is being made with effective methods of integrated pest management in headed cabbage and this may reduce pesticide use. Cultivars resistant to cabbage yellows and black rot are becoming increasingly available. However, club root is spreading fast in areas with intensive market gardening and cultivars with durable resistance will not be available in the medium term. Methods of control by antagonists to the pathogen and cultural methods deserve more attention.

The development of DNA markers by plant biotechnology for more precise indirect screening for resistance to diseases and pests, as well as other characteristics, will considerably increase breeding efficiency in headed cabbage. The seeds of Japanese hybrids are still mainly produced by self-incompatibility, but several European and American seed companies are quickly changing over to the CMS system, because of lower seed production costs and better seed quality (no inbreds). A few smaller European seed companies producing 'biological' seed for organic farming have refused to adopt CMS in *Brassica* vegetable seed production.

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Sources of illustration van der Vossen, H.A.M., 1993b.

Authors H.A.M. van der Vossen & A.A. Seif
Based on PROSEA 8: Vegetables.

BRASSICA OLERACEA L. (cauliflower and broccoli)

Protologue Sp. pl. 2: 667 (1753).
Family Brassicaceae (Cruciferae)
Chromosome number $2n = 18$
Vernacular names

- Cauliflower (En). Chou-fleur (Fr). Couve flor (Po).
- Broccoli, sprouting broccoli, calabrese (En). Brocoli, chou brocoli (Fr). Brócolos, couve brócolo (Po).

Origin and geographic distribution Cauliflower and broccoli probably evolved in Roman times from wild or primitive cultivated forms of *Brassica oleracea* from the eastern Mediterranean region. A remarkable diversity of cauliflower and broccoli-like vegetables developed in Italy. During the last 400 years, white-headed cauliflower spread from Italy to central and northern Europe, which became secondary centres of diversity for annual and biennial types. Cauliflower adapted to hot and humid tropical climates has evolved in India during the last 200 years from biennial cauliflower of mainly British and central European origin. Broccoli with one main green 'head' (calabrese) was introduced into the United States by Italian immigrants during the early 20th century. From the United States it has spread throughout the world in the last 50 years. In tropical Africa cauliflower and broccoli are grown, usually on a small scale, in many countries with highland areas, in West Africa occasionally also in lowland areas during the cool harmattan season.

Uses Cauliflower and broccoli are grown for their large, edible, very young inflorescence. Cauliflower heads (curds) and in broccoli the heads and the fleshy upper portion of the stem are mostly consumed as a cooked vegetable; sometimes they are cut into small pieces (florets) and used raw in mixed salads or in pickles. Broccoli, and to a lesser extent cauliflower, have become popular as quick-frozen vegetables, particularly in the United States and Europe. Both are also processed in mixtures of dried vegetables.

Production and international trade Total world production of cauliflower in 2002 was estimated at 15.3 million t per year from 812,000 ha. Major cauliflower producing areas are China 303,000 ha, India 260,000 ha, Europe 120,000 ha, North America 37,000 ha, Middle East 20,000 ha, Japan 10,000 ha and North Africa 11,000 ha. World statistics on broccoli production are incomplete and often mixed with cauliflower data. Important broccoli producing areas are: North America 56,000 ha, Europe 45,000 ha, Latin America 8000 ha and Asia 17,000 ha. In tropical Africa cauliflower and broccoli are minor crops; statistical data are very incomplete.

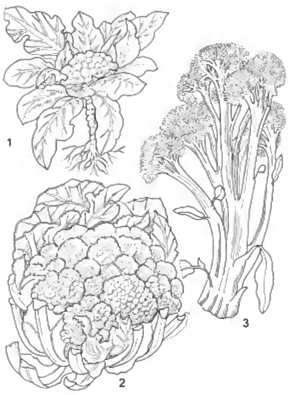
Properties Cauliflower contains per 100 g edible portion (florets only, 45% of product as purchased): water 88.4 g, energy 142 kJ (34 kcal), protein 3.6 g, fat 0.9 g, carbohydrate 3.0 g, dietary fibre 1.8 g, Ca 21 mg, Mg 17 mg, P 64 mg, Fe 0.7 mg, Zn 0.6 mg, carotene 50 µg, thiamin 0.17 mg, riboflavin 0.05 mg, niacin 0.6 mg, folate 66 µg, ascorbic acid 43 mg. Raw green broccoli contains per 100 g edible portion (tough stems removed, 61% of product as purchased): water 88.2 g, energy 138 kJ (33 kcal), protein 4.4 g, fat 0.9 g, carbohydrate 1.8 g, dietary fibre 2.6 g, Ca 56 mg, Mg 22 mg, P 87 mg, Fe 1.7 mg, Zn 0.6 mg, carotene 575 µg, thiamin 0.10 mg, riboflavin 0.06 mg, niacin 0.9 mg, folate 90 µg, ascorbic acid 87 mg (Holland, B., Unwin, I.D. & Buss, D.H., 1991). Both vegetables have a high nutritional value, but broccoli scores overall higher than cauliflower. Broccoli is rich in Se, containing 3 µg/100 g.

Like all *Brassica* crops, cauliflower and broccoli contain various bioactive compounds such as flavonoids and hydroxycinnamoyl derivatives. They also contain glucosinolates, which are

responsible for the characteristic flavour and taste, and some of them have strong anticarcinogenic properties. In cauliflower the main glucosinolate is sinigrin, in broccoli glucoraphanin. Sulforaphane, a breakdown product of glucoraphanin, has shown anticancer activity in rats and humans against several forms of cancer. It is a potent inducer of enzymes that protect cells against electrophile toxins including carcinogens; it also upregulates the synthesis of hepatic detoxification enzymes. The glucosinolate content is influenced by ecological factors (e.g. soil S content) and cultivar. 'Brigadier', 'Majestic' and 'Wintergarden' are particularly rich in glucoraphanin. Although the concentration of glucoraphanin is highest in the seed, the total amount accumulated is highest at the green head stage.

Description Erect, glabrous, annual or biennial herb up to 80 cm tall at the mature vegetative stage, up to 150 cm when flowering, with unbranched stem thickening upwards; root system strongly branched. Leaves alternate but closely arranged and more or less erect, forming a rosette surrounding the young inflorescence especially in cauliflower, usually simple; stipules absent; leaves almost sessile, but often shortly petiolate in broccoli; blade ovate to oblong, up to 80 cm × 40 cm, undulate or irregularly incised to almost entire, coated with a layer of wax, blue-green with whitish veins. Inflorescence a terminal paniculate raceme up to 70 cm long, when young (curd or head) composed of more or less densely arranged branching partial inflorescences and fleshy peduncles, in cauliflower up to 30 cm in diameter, very solid and globular to rather loose and flat, white to green, in broccoli less densely arranged with longer peduncles, green to purple. Flowers bisexual, regular, 4-merous; pedicel up to 2 cm long, ascending; sepals oblong, c. 1 cm long, erect; petals obovate, 1.5–2.5 cm long, clawed, pale to bright yellow or whitish; stamens 6; ovary superior, cylindrical, 2-celled, stigma globose. Fruit a linear silique 5–10 cm × c. 5 mm, with a tapering beak 5–15 mm long, dehiscent, up to 30-seeded. Seeds globose, 2–4 mm in diameter, finely reticulate, brown. Seedling with epigeal germination, with a taproot and lateral roots; hypocotyl 3–5 cm long, epicotyl absent; cotyledons with petiole 1–2 cm long, blade cordate, 1–1.5 cm long, cuneate at base, notched at apex.

Other botanical information Cauliflower and broccoli have been classified in convar. *botrytis* (L.) Alef., as var. *botrytis* L. and var.



Brassica oleracea (cauliflower and broccoli) – 1, plant habit (cauliflower); 2, young inflorescence (cauliflower); 3, young inflorescence (broccoli). Source: PROSEA

italica Plenck, respectively. They can best be considered as cultivar-groups and as such have been called Cauliflower Group and Broccoli Group. Both groups are sometimes subdivided into several smaller ones, but such classifications are of no relevance in tropical Africa. Modern cauliflower cultivars can also be grouped according to their horticultural characteristics: temperate biennial winter cultivars (frost resistant or not frost resistant), temperate annual cultivars (spring, summer and autumn cultivars) and tropical cultivars. Temperate summer cultivars and increasingly tropical cultivars are grown in tropical Africa, but the last group of cultivars, adapted to hot and humid climates, is most suitable. Popular cultivars like 'Patna', 'Agahani' and 'Kartika' were developed in India from landraces. These selections are of rather poor quality. Modern F_1 hybrids developed in Japan, China and India, combining good quality with heat tolerance, are rapidly replacing the old landraces.

In broccoli the single headed 'calabrese' type with a compact dome-shaped head with small beads (flower buds) is grown worldwide, under conditions comparable to the summer types of

temperate cauliflower. The buds are preferably dark green.

Growth and development Cauliflower and broccoli seed (6% moisture content) will remain viable for at least 4–6 years when stored dry at temperatures below 18°C. Seeds germinate within 3–6 days and seedlings have 7–9 true leaves within 30–40 days at > 20°C average daily temperatures.

Differentiation of floral primordia in cauliflower can only start at the end of the juvenile phase, when plants have 12–15 leaves for early types to more than 30 leaves for late biennial types. Good curd induction requires a subsequent period of 20–30 days at relatively low night temperatures of 10–15°C for temperate and 18–22°C for tropical cultivars. Higher than optimum temperatures during this period will cause delayed curd formation and defects such as fuzziness and bracting (development of bracts, which may grow through the curd surface). Premature flower bud formation causing a rough granular appearance can occur when the temperature is below optimum. Curd induction requirements of most broccoli cultivars are similar to those of temperate summer cauliflower. Heads of annual cauliflower and broccoli are ready for harvesting 75–150 days after sowing, depending on cultivar and climate.

Very soon after the optimum harvesting date, curds of cauliflower plants start to enlarge, become loose, the peduncles lengthen and turn green and the floral meristems develop into inflorescences. Particularly in modern cauliflower cultivars with very firm and dense curds, only the outer rim of the curd develops flowers, with the rest aborting and becoming a substrate for pathogenic fungi under humid conditions. In broccoli the head is a mass of fully developed flower buds and normally very little abortion takes place.

Flowering starts at the base of the inflorescences and continues for about one month in cauliflower and for 20–25 days in broccoli plants. Insects, especially bees, effect pollination. Seeds are mature 45–50 days after anthesis.

Ecology Temperate summer cultivars of cauliflower and broccoli can be grown in the tropics when maximum temperatures do not exceed 30°C and night temperatures drop below 18°C for about four weeks about one month after planting to ensure good curd induction. In subtropical areas these conditions often occur in the dry winter season. In the equatorial areas these conditions can be found at elevations above 1000 m, at higher latitudes in the tropics during the dry winter season. In tropical lowland conditions only adapted tropical types can be grown, but their weight and quality are in general inferior to temperate types. For successful seed production a fairly cool and dry climate is a prerequisite.

Soils should be well drained and fertile, with good moisture retaining capacity and a high organic matter content; the optimum pH is 6.5–7.5.

Propagation and planting Seed of cauliflower and broccoli is mostly sown on seedbeds, sometimes in soil blocks or modules. The 1000-seed weight is 2.5–4 g, the seed requirement 100–200 g/ha. Dormancy of freshly harvested seed can be reduced by overnight soaking and rinsing in water; it also disappears after 3–4 months storage, so seed from seed companies is not dormant. Young seedlings may have to be shaded to prevent sun scorching. Transplanting to the field should be done when seedlings have 7–9 true leaves, 30–40 days after sowing. Plant densities for cauliflower are 15,000–35,000 plants/ha; for broccoli similar or somewhat higher densities are applied. Vegetative propagation of broccoli plants is possible by rooting and transplanting of lateral shoots. In cauliflower lateral shoots are not available, but propagation through tissue culture from young floral meristems is easy to realize. This is only practised in breeding programmes to maintain selected plants.

Management Soil preparation includes deep digging, mixing with compost or stable manure (20 t/ha), followed by fine tillage. NPK fertilizers – type and rates depending on soil type, mineral reserves in the soil and expected yields – are applied before planting; another two or three N fertilizer dressings are applied later to stimulate good head formation. A high-yielding crop needs about 220 kg N, 25–40 kg P and 200–300 kg K per ha. Nitrogen deficiency at the early growth stage will cause 'buttoning': stunted plants with reduced leaf and head development. Cauliflower and broccoli have a high demand for Mg, Bo and Mo. Applications of dolomite limestone, borax and ammonium molybdate may be necessary to prevent physiological disorders, such as browning of the head and plants without a heart. Deficiencies occur more commonly on acid soils.

A regular water supply is required throughout the growing season, but the heads of cauliflower and broccoli are easily affected by fungal rots when continuously exposed to wet conditions. Therefore, the mature plant stage and

harvesting should be planned as much as possible outside the rainy season and overhead irrigation should be avoided.

The young crop should be kept free of weeds. Mulching, e.g. with rice straw, is beneficial to growth as it retains moisture, keeps soil temperatures down and suppresses weeds. Growth of the plant should be regular and undisturbed. Sudden increases in temperature or water stress may cause the formation of bracts, fuzziness or splitting of cauliflower curds and irregular head formation and premature flowering in broccoli. Maturing cauliflower curds must be protected from direct sunlight by covering with broken-off leaves to prevent them from turning yellow and/or pink. Many modern cultivars are self-protecting, i.e. inner leaves wrap tightly around the curd.

Diseases and pests Diseases and pests are similar to those of cabbage in tropical regions. For important diseases such as Fusarium yellows (*Fusarium oxysporum* f.sp. *conglutinans*), downy mildew on leaves and heads (*Peronospora parasitica*), black rot (*Xanthomonas campestris* pv. *campestris*) and club root (*Plasmodiophora brassicae*), resistance or field tolerance have been found in cauliflower and broccoli accessions, but the majority of present-day cultivars are still susceptible. A pH of 7 is recommended to prevent club root damage. Other diseases causing problems are the seedborne diseases black leg (*Leptosphaeria maculans*; asexual form: *Phoma lingam*) and *Alternaria* blight (*Alternaria brassicae*), and the not seedborne diseases powdery mildew (*Erysiphe polygoni*), damping off (*Pythium ultimum*), stem rot (*Rhizoctonia solani*), bacterial soft rot (*Erwinia carotovora*) as storage disease, cauliflower mosaic virus (CaMV) and turnip mosaic virus (TuMV). Root-knot nematodes (*Meloidogyne* spp.) can be a serious problem and should be avoided by proper crop rotation.

Important pests are diamondback moth (*Plutella xylostella*), cut worm (*Agrotis* spp. and *Spodoptera littoralis*), cabbage root fly (*Delia radicum*), cabbage moth (*Crocidolomia binotalis*), cabbage butterfly (*Pieris* spp.) and aphids (*Aphis* spp. and *Brevicoryne brassicae*), the vectors of CaMV and TuMV. Diamondback moth is extremely noxious because it quickly develops resistance to many insecticides, and because of the small size of the larvae and pupae, which makes removal virtually impossible. Methods of integrated pest management applied to cabbage (using parasitoids, sex pheromones, trap plants and very restricted chemical control) can also be effective in cauliflower and broccoli.

Harvesting Annual cauliflower and broccoli are ready for harvesting 60–150 days after transplanting; some early heat-tolerant cultivars, mainly F_1 hybrids, are even ready within 40–55 days in tropical regions. Harvesting takes place over a period of 1–2 weeks. Modern F_1 hybrids can be harvested in 2–3 cuttings.

Cauliflower heads are cut with sufficient trimmed leaves still attached to protect the curds during packing and transport. Broccoli heads are harvested with 10–15 cm of stem, without leaves.

Yield Cauliflower yields can attain 12–30 t/ha and broccoli yields 10–15 t/ha; in the tropics the highest yields are obtained above 1000 m altitude. Seed yields are 200–600 kg/ha in temperate climates.

Handling after harvest Cauliflower and broccoli heads will deteriorate quickly unless cooled soon after harvesting. Cauliflower curds can be stored for about 3 weeks at 1°C and 95% relative humidity, but storage life for broccoli is much shorter and heads are usually wrapped in polythene film to prevent rapid desiccation and yellowing.

Genetic resources In temperate regions F_1 hybrids have completely replaced the landraces as well as the open-pollinated improved cultivars of both cauliflower and broccoli. This process is also taking place in tropical regions, hence the need to collect tropical landraces. Germplasm collections of cauliflower and broccoli are available in several genebanks, particularly in Europe, the United States, India, China and Japan. In Europe a *Brassica* genebank has been established in co-operation with private companies. A central electronic catalogue of the collections is available at the Centre for Genetic Resources (CGN), Wageningen, Netherlands. While genetic erosion reduces the existing variability, interspecific crosses within the *Brassicaceae* family widens the genepool available to breeders.

Breeding F_1 hybrids based on a single cross between two inbred lines are the only goal of the breeding programmes of seed companies and most government institutes. Until recently commercial hybrid seed production was based on sporophytic self-incompatibility (SI), a 1-locus system with multiple alleles that precludes self-fertilization in most cauliflower and broccoli. Exceptions are the annual cauliflower types developed in northern Europe, which are selected for self-fertility (absence of S-alleles).

Bud pollination or treatment with CO_2 (4–7%) after bee pollination prevent the self recognition reaction. These methods are used in breeding programmes to develop and maintain inbred lines. Since about 1995 F_1 hybrids based on the SI system are gradually being replaced by hybrids based on cytoplasmic male sterility (CMS).
Inbred lines are increasingly developed from plants regenerated from anther and microspore cultures. DNA-markers are used for precise screening for resistance to diseases and other important traits. The main breeding objectives include: curd quality, yield, earliness, stress tolerance and resistance to diseases. Some breeding companies in Western countries focus on increasing the content of anticarcinogenic glucosinolates in broccoli.

Prospects Breeding companies and institutes in India, China and Japan are developing heat-tolerant cultivars, which will result in a more reliable production with better quality in tropical conditions. Considerable progress is being made with effective methods of integrated pest management, as in cabbage, and this will reduce pesticide use. Cultivars resistant to fusarium yellows, downy mildew and clubroot will become available within five years. Resistance to black rot will take another five years. Consequently, cauliflower and broccoli are expected to become more important in tropical Africa. Information on cauliflower and broccoli production in tropical Africa is scarce, but valuable data can be found in the literature from tropical Asia.

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Sources of illustration van der Vossen, H.A.M., 1993a.

Authors P. Tjeertes
Based on PROSEA 8: Vegetables.

BRASSICA OLERACEA L. (Brussels sprouts)

Protologue Sp. pl. 2: 667 (1753).
Family Brassicaceae (Cruciferae)
Chromosome number $2n = 18$

Vernacular names Brussels sprouts (En). Chou de Bruxelles (Fr). Couve de Bruxelas (Po).

Origin and geographic distribution The origin of Brussels sprouts lies in Belgium, where it was first mentioned at the end of the 18th Century. It spread from there to the rest of north-western Europe, where it is an important autumn and winter crop. In tropical Africa it is very rare, only occasionally grown in the highlands above 2000 m for people of European origin.

Uses Brussels sprouts is grown for the enlarged buds (sprouts) formed in the leaf axils of the erect long-stemmed plant. The sprouts, resembling very small cabbages, are consumed as a cooked vegetable and mostly purchased as a fresh product, although in recent years the frozen product has gained in popularity.

Properties The nutritional composition of Brussels sprouts per 100 g edible portion (69% of the product as purchased, base trimmed, outer leaves removed) is: water 84.3 g, energy 177 kJ (42 kcal), protein 3.5 g, fat 1.4 g, carbohydrate 4.1 g, dietary fibre 4.1 g, Ca 26 mg, Mg 8 mg, P 77 mg, Fe 0.7 mg, Zn 0.5 mg, carotene 215 μg, thiamin 0.15 mg, riboflavin 0.11 mg, niacin 0.2 mg, folate 135 μg, ascorbic acid 115 mg (Holland, B., Unwin, I.D. & Buss, D.H., 1991). Glucosinolates determine the characteristic flavour and taste.

Botany Erect, glabrous, biennial herb up to 120 cm tall, with unbranched stem, developing lateral buds (sprouts) in leaf axils; root system strong and branched. Leaves alternate, simple or lower ones with some small side lobes at base; stipules absent; all leaves with distinct petiole, but upper ones with short petiole giving the top of the plant a rosette-like appearance; blade more or less circular, undulate or irregularly incised, blue-green. Inflorescence a terminal paniculate raceme. Flowers bisexual, regular, 4-merous; pedicel up to 2 cm long, ascending; sepals oblong, c. 1 cm long, erect; petals obovate, 1.5–2 cm long, clawed, pale to bright yellow or whitish; stamens 6; ovary superior, cylindrical, 2-celled, stigma globose. Fruit a linear silique 5–10 cm × c. 5 mm, with a tapering beak 5–15 mm long, dehiscent, up to 30-seeded. Seeds globose, 1.5–2 mm in diameter, finely reticulate, dark brown. Seedling

with epigeal germination, with a taproot and lateral roots; hypocotyl 3–5 cm long, epicotyl absent; cotyledons with petiole 1–2 cm long, blade cordate, 1–1.5 cm long, cuneate at base, notched at apex.

Brussels sprouts has been classified as var. *gemmifera* DC. or convar. *gemmifera* (DC.) Gladis. It can best be considered as a cultivar-group and as such has been called Brussels Sprout Group.

Breeders have developed early (summer), mid-early and late (winter) types, and together with variation in planting time, growers in Europe can plan the production of Brussels sprouts from the end of August till March.

Ecology Brussels sprouts is adapted to a cool and rather humid climate. Most production takes place in coastal areas of north-western Europe. Only the early types can be cultivated in high-altitude regions of the tropics or during the winter season in the subtropics.

Management Seeds are sown on seedbeds or modules. Young seedlings need shading to prevent sun scorch. The 1000-seed weight is 3–5 g; seed requirement 160–200 g/ha. Transplanting to the field should be done when seedlings have 7–9 true leaves, 30–40 days after sowing. Plant density is 30,000–40,000 plants/ha.

Soil preparation includes deep digging, followed by fine tillage. NPK fertilizers – type and rates depending on soil type, mineral reserves in the soil and expected yields – are applied before planting; another one or two N fertilizer dressings are applied for continued growth. A high-yielding crop needs 180–200 kg N, 140 kg P and 500 kg K per ha.

A pH of 7 is recommended to prevent clubroot damage. Sowing, planting and harvesting of Brussels sprouts is highly mechanized in Europe, where the crop is harvested with a single cutting. Home gardeners, and small-scale African producers, can better harvest the sprouts in several rounds of hand picking. The yield of early types is about 14 t/ha. Sprouts can be stored under controlled conditions for 6–10 weeks. Diseases and pests are the same as for headed cabbage. Considerable progress is being made with effective methods of integrated pest management.

Genetic resources and breeding Germplasm collections of Brussels sprouts are available in several European genebanks, e.g. at the Centre for Genetic Resources (CGN), Wageningen, Netherlands. The possibility of interspecific hybridization within the *Brassicaceae* family makes the genepool very wide.

The main breeding objectives include quality, yield, earliness, stress tolerance and resistance to diseases (e.g. clubroot). Seed companies focus exclusively on the production of single-cross F_1 hybrids. During the last forty years breeders have changed the shape of the plants from a pyramidal sprout setting, with big sprouts at the bottom and small ones at the top, to a plant type with a cylindrical sprout setting with all sprouts of the same size, suitable for once-over mechanical harvesting. As in the other *Brassica* vegetables, hybrids based on self incompatibility are now being replaced by hybrids based on cytoplasmic male sterility. Increasingly, inbred lines are being developed from anther and microspore cultures. DNA-markers are used for precise screening for resistance to diseases and other important traits.

Prospects Brussels sprouts will remain a rather insignificant vegetable for tropical Africa, unless heat-tolerant cultivars become available, in which case Brussels sprouts might become interesting for African highlands as a high-yielding and nutritious vegetable.

Major references Holland, B., Unwin, I.D. & Buss, D.H., 1991; Jansen, P.C.M., Siemonsma, J.S. & Narciso, J.O., 1993; Nieuwhof, M., 1969; Salunkhe, D.K. & Kadam, S.S., 1998; Shinohara, S., 1984.

Other references Buishand, T., Houwing, H.P. & Jansen, K., 1986; Crisp, P. et al., 1989; Pelletier, G.R., 1986; Pelletier, G.R., 1989; Rubatzky, V.E. & Yamaguchi, M., 1997; Taylor, J.P., 1982; Verkerk, R., 2002.

Authors P. Tjeertes

BRASSICA OLERACEA L. (kohlrabi)

Protologue Sp. pl. 2: 667 (1753).

Family Brassicaceae (Cruciferae)

Chromosome number $2n = 18$

Vernacular names Kohlrabi, cabbage turnip, knolkhol (En). Chou-rave (Fr). Couve rabano (Po).

Origin and geographic distribution The origin of kohlrabi lies in north-western Europe, where it was developed from marrow-stem kale, a fodder crop with a thickened stem. The first record dates from the 16th century. Besides in Europe, North America and temperate parts of Asia, kohlrabi is also grown in subtropical Asia, e.g. in India, China and northern Vietnam. At high elevations in East Africa it is

occasionally grown for European clients.

Uses Kohlrabi is grown for the flattened globose to ovoid swollen stem (stem tuber), which is cut in pieces and cooked, but also used in soups or eaten raw in salads. Industrially it is made into deep-frozen products.

Properties Kohlrabi stem tubers (peeled thickly, 70% of product as purchased) contain per 100 g edible portion: water 91.7 g, energy 96 kJ (23 kcal), protein 1.6 g, fat 0.2 g, carbohydrate 3.7 g, dietary fibre 2.2 g, Ca 30 mg, Mg 10 mg, P 35 mg, Fe 0.3 mg, Zn 0.1 mg, carotene trace, thiamin 0.11 mg, riboflavin trace, niacin 0.3 mg, folate 82 µg, ascorbic acid 43 mg (Holland, B., Unwin, I.D. & Buss, D.H., 1991). Kohlrabi is rich in glucosinolates; properly prepared it contains per 100 g about 100 mg glucosinolates, mainly indolylglucosinolate. Glucosinolates determine the characteristic flavour and taste, and are known to have anticarcinogenic activity.

Botany Erect, glabrous, biennial herb up to 40 cm tall at the mature vegetative stage, with unbranched, swollen, tuber-like stem up to 12 cm in diameter, pale green to purplish; root system strongly branched. Leaves alternate, simple or with some small side lobes at base; stipules absent; all leaves with distinct, slender petiole; blade ovate in outline, irregularly incised, blue-green. Inflorescence a terminal paniculate raceme. Flowers bisexual, regular, 4-merous; pedicel up to 2 cm long, ascending; sepals oblong, c. 1 cm long, erect; petals obovate, 1.5–2 cm long, clawed, pale to bright yellow or whitish; stamens 6; ovary superior, cylindrical, 2-celled, stigma globose. Fruit a linear silique 5–10 cm × c. 5 mm, with a tapering beak 5–15 mm long, dehiscent, up to 30-seeded. Seeds globose, 1.5–2 mm in diameter, finely reticulate, brown. Seedling with epigeal germination, with a taproot and lateral roots; hypocotyl 3–5 cm long, epicotyl absent; cotyledons with petiole 1–2 cm long, blade cordate, 1–1.5 cm long, cuneate at base, notched at apex.

Brassica oleracea (kohlrabi) – plant habit. Source: PROSEA

Kohlrabi has been classified in convar. *acephala* (DC.) Alef., as var. *gongylodes* L. It can best be considered as a cultivar-group and as such has been called Kohlrabi Group.

Ecology Kohlrabi is adapted to a temperate climate. In north-western Europe production is from March till November, but in subtropical regions (e.g. Vietnam) it is grown during the cool winter season. Only the early types adapted to summer conditions of temperate climates are used for cultivation in high-altitude regions of the tropics or in the cool season of the subtropics.

Management Seeds are sown on seedbeds or modules. The 1000-seed weight is 3–5 g. Young seedlings may have to be shaded to prevent sun scorching. Seed requirements are 300–700 g/ha. Transplanting to the field should be done when seedlings have 7–9 true leaves, 30–40 days after sowing. Plant densities are 100,000–120,000 plants/ha. In mechanized cultivation kohlrabi may be sown direct at a rate of 1–2 kg/ha and later thinned to a density of up to 300,000 plants per ha. Cultivation practices and use of fertilizers are comparable to cauliflower. Diseases and pests are the same as for the other vegetable *Brassica* crops. Kohlrabi should be harvested when young (55–65 days after sowing) as the roots become woody and fibrous with age. To obtain a tender, sweet product from spring-sown kohlrabi the stem tubers are picked when 5–6 cm in diameter; those of autumn-grown kohlrabi are less likely to become fibrous and can be harvested when 10–12 cm in diameter.

Yield for fresh market is about 36 t/ha, but for industry yields can be achieved of 100 t/ha. Kohlrabi stem tubers can be stored for about three weeks at 0–1°C and a relative humidity of 98%; topped ones may be stored for 2–3 months under these conditions.

Genetic resources and breeding Germplasm collections of kohlrabi are available in several genebanks. In Europe a *Brassica* genebank has been established in cooperation with private companies. A database is available at the Centre for Genetic Resources (CGN),

Wageningen, Netherlands.
Seed companies have developed F1 hybrids based on self-incompatibility and a single cross between two inbred lines. The first hybrid based on cytoplasmic male sterility was recently released. The main breeding objectives are uniformity, yield, earliness, colour and stem tuber quality. Important cultivars include 'Kossak', 'Kolibri F1' and 'Grand Duke'.

Prospects Kohlrabi is of minor importance for tropical Africa, but introduction of heat tolerant cultivars (e.g. from northern Vietnam) might lead to some expansion.

Major references Holland, B., Unwin, I.D. & Buss, D.H., 1991; Jansen, P.C.M., Siemonsma, J.S. & Narciso, J.O., 1993; Nieuwhof, M., 1969; Oregon State University, 2002; Salunkhe, D.K. & Kadam, S.S., 1998.

Other references Buishand, T., Houwing, H.P. & Jansen, K., 1986; Crisp, P. et al., 1989; Pelletier, G.R., 1989; Shinohara, S., 1984; Taylor, J.P., 1982.

Sources of illustration Jansen, P.C.M., Siemonsma, J.S. & Narciso, J.O., 1993.

Authors P. Tjeertes

BRASSICA RAPA L.

Protologue Sp. pl. 2: 666 (1753).
Family Brassicaceae (Cruciferae)
Chromosome number $2n = 20$
Synonyms *Brassica campestris* L. (1753).
Vernacular names
- Neep crops (En).
- Chinese cabbage, petsai, pe-tsai (En). Pétsaï, chou chinois (Fr). Couve petsai (Po).
- Pakchoi, pak-choi, celery cabbage, bok choi (En). Pakchoï, pakchoy, chou de Shanghaï, chou chinois (Fr). Couve chinesa, couve da China (Po).
- Caisin, caisim, cai xin, choisum, choi-sum (En). Choy sum, brocoli chinois (Fr). Couve d'inflorescência (Po).
- Turnip (En). Navet, rave (Fr). Nabo (Po).

Origin and geographic distribution The origin of *Brassica rapa* is not known; the area extending from the eastern Mediterranean to Pakistan and eastern China has been suggested. Turnip is the oldest *Brassica rapa* vegetable. It was described at the times of Alexander the Great (356–323 BC), whose empire included the Middle East and Persia. From there it is supposed to have spread to South-East Asia and Africa via trade routes. The wide variation in *Brassica rapa*, together called neep crops, evolved in different parts of the Eurasian continent. Chinese cabbage and pakchoi developed in temperate regions of eastern Asia and caisin probably in subtropical regions of China. Vegetable turnip is highly regarded in Japan, and rather popular in Europe. Oil-seed types, including turnip rape and the southern Asian crops sarson and toria, are grown for rape-oil, with production centres in India, China, Canada and Australia.

Brassica rapa – planted

In tropical Africa *Brassica rapa* is occasionally reported as a cultivated vegetable in many countries, and is likely to occur in all countries. Chinese cabbage is most common, recorded as locally rather popular e.g. in Cameroon and DR Congo, followed by turnip, whereas pakchoi and caisin are found in areas with people of Asian origin. Caisin has been reported from Sierra Leone and is quite popular in Congo, where it is called 'loundif' in the Lengvele language, and mistakenly 'endive' in French.
Brassica rapa has also been recorded as a weed, e.g. in Eritrea, Ethiopia, Kenya, Uganda, Tanzania, Zimbabwe and Mozambique, probably as an escape from cultivation.

Uses *Brassica rapa* comprises many crops with a variety of uses. Most important are the vegetables. The foliage of Chinese cabbage, pakchoi and caisin and the thickened taproot of vegetable turnip are used as vegetables. They are consumed boiled, in soups, fresh in salads, or stir-fried in special dishes. Caisin plants are often consumed in the flowering stage. When stir-fried, the smooth and tender petioles and peduncle retain a pleasing crispness. Chinese cabbage and pakchoi leaves are also eaten pickled. In Europe, special cultivars of turnip are

important as fodder crop. *Brassica rapa* oil crops are of no importance in tropical Africa, but may be important elsewhere, e.g. in India, Canada and France, together with cultivars of *Brassica juncea* (L.) Czern. and *Brassica napus* L.

Production and international trade Chinese cabbage, pakchoi and caisin are leading market vegetables in China, Japan and South-East Asia, grown on more than 500,000 ha. Vegetable turnip is rather important in Japan and Europe. In tropical Africa Chinese cabbage and turnip are rather common in city markets, but pakchoi and caisin are of minor importance. All *Brassica rapa* types are grown occasionally for specialized markets in major cities for consumers of Asian and – to a lesser degree – European origin. No statistical data on yield and trade are known, but international trade is probably limited to some occasional export from East Africa to Europe and Arab countries.

Properties The nutritional composition of Chinese cabbage is per 100 g edible portion (93%): water 94.4 g, energy 67 kJ (16 kcal), protein 1.2 g, fat 0.2 g, carbohydrate 3.2 g, dietary fibre 1.2 g, Ca 77 mg, Mg 13 mg, P 29 mg, Fe 0.31 mg, Zn 0.23 mg, vitamin A 318 IU, thiamin 0.04 mg, riboflavin 0.05 mg, niacin 0.4 mg, folate 79 μg, ascorbic acid 27 mg. Raw pakchoi contains per 100 g edible portion (88%): water 95.3 g, energy 54 kJ (13 kcal), protein 1.5 g, fat 0.2 g, carbohydrate 2.2 g, dietary fibre 1.0 g, Ca 105 mg, Mg 19 mg, P 37 mg, Fe 0.8 mg, Zn 0.2 mg, vitamin A 4468 IU, thiamin 0.04 mg, riboflavin 0.07 mg, niacin 0.5 mg, folate 66 μg, ascorbic acid 45 mg. The nutritional composition of turnip roots is per 100 g edible portion (81%): water 92 g, energy 117 kJ (28 kcal), protein 0.9 g, fat 0.1 g, carbohydrate 6.4 g, dietary fibre 1.8 g, Ca 30 mg, Mg 11 mg, P 27 mg, Fe 0.3 mg, Zn 0.3 mg, vitamin A absent, thiamin 0.04 mg, riboflavin 0.03 mg, niacin 0.4 mg, folate 15 μg, ascorbic acid 21 mg (USDA, 2002). Leaf and root extracts of *Brassica rapa* showed antibacterial and antifungal activities.

Description Erect, annual to biennial herb up to 1.5 m tall, with stout taproot, sometimes partly swollen (turnip); stem branched. Leaves arranged spirally but in a rosette during the vegetative stage; stipules absent; lower leaves more or less petiolate, pinnately parted with 1–5 pairs of small lateral lobes and large terminal lobe up to 90 cm × 35 cm, crenate, toothed, sinuate or entire, usually hairy; stem leaves pinnately parted to simple, clasping at base, glabrous, glaucous. Inflorescence a terminal umbel-like raceme up to 60 cm long, with open flowers overtopping the buds, elongating in fruit. Flowers bisexual, regular, 4-merous; pedicel up to 3 cm long, ascending; sepals 5–8 mm long, spreading, yellow-green; petals obovate, 0.5–1 cm long, clawed, bright yellow; stamens 6; ovary superior, cylindrical, 2-celled, stigma globose. Fruit a linear silique 4–10 cm × 2–4 mm, with a tapering beak 0.5–3 cm long, dehiscent, up to 30-seeded. Seeds globose, 1–1.5 mm in diameter, finely reticulate, dark brown. Seedling with epigeal germination, with a taproot and lateral roots; hypocotyl c. 5 cm long, epicotyl 2–4 mm long; cotyledons with petiole c. 2 cm long, blade cordate, 1–1.5 cm long, cuneate at base, notched at apex.

Brassica rapa – 1, plant habit of turnip; 2, plant habit of caisin; 3, plant habit of Chinese cabbage; 4, head of Chinese cabbage; 5, plant habit of pakchoi.
Redrawn and adapted by Iskak Syamsudin

Other botanical information The taxonomy of *Brassica rapa* is confused. Several infraspecific classifications have been proposed, each trying to capture the wide variation of the cultivated taxa in one taxonomical system, the result always being unsatisfactory. A classifi-

cation in cultivar-groups has been made and of the approximately 12 distinguished, the following are of at least some importance for tropical Africa:

- Chinese Cabbage Group (synonym: *Brassica pekinensis* (Lour.) Rupr.): producing short barrel-shaped to long torpedo-shaped heads, more or less tight but never as tight as in *Brassica oleracea* L. (headed cabbage).
- Pak Choi Group (synonym: *Brassica chinensis* L.): producing a loose rosette of leaves, petioles enlarged, flattened, fleshy.
- Caisin Group (synonym: *Brassica parachinensis* L.H.Bailey): producing a loose rosette with orbicular basal leaves, hardly winged petioles and non-clasping stem leaves, plants harvested before flowering or when the first flowers appear.
- Vegetable Turnip Group: producing a swollen root (hypocotyl), varying in shape from flattened globose to ellipsoid and cylindrical, blunt or sharply pointed, and in colour from white to pink or yellow, apex white, green, red, pink or bronze, leaves sometimes also used as a vegetable.

Several other groups of oriental vegetables are part of *Brassica rapa* but are practically unknown in Africa. These include the leafy vegetables Mizuna Group, Neep Greens Group and Taatsai Group.

Growth and development *Brassica rapa* seed has no dormancy, but it is advisable to wait for at least one week after seed drying before sowing. The seeds require 3–5 days to germinate under optimum soil moisture and temperature (20–25°C). Germination is not influenced by light. *Brassica rapa* plants can be vernalized by low temperatures at a young stage.

Chinese cabbage seedlings normally develop 5 leafs in two whorls (early type) or 8 leaves in three whorls (late type). At this stage, when the leaves are still horizontal, the plants are transplanted to the field. New inner leaves then start to grow more upright. Heading can start at the 12th leaf stage for early cultivars and at the 25th leaf stage for late ones. The heads can be harvested 40–80 days after sowing. In comparison with early cultivars, late ones have both more and larger non-heading leaves and more leaves forming the head (up to 100 leaves for late types). Bolting starts with elongation of the thick short stem while flower buds develop. Biennial types bolt after a period of relatively low temperature.

Pakchoi is non-headed. The first two true leaves are opposite, later leaves are arranged spirally. At the harvest stage (after 40–45 days) a plant will have about 30 leaves: 10 juvenile, 14 fully expanded and 6 small inner leaves.

Caisin has a small number of large elliptical leaves on a relatively thin stem. It bolts 30–80 days after sowing and bolting is less temperature-dependent than in Chinese cabbage.

Turnip can be frost tolerant and is able to germinate far below the optimum temperature (starting 5 °C). In 3 weeks the plant develops a strong taproot, 5–7 leaves and becomes 10–15 cm tall. Part of the root but mainly the hypocotyl will thicken as storage organ. In plants less than 10 weeks old, bolting can be induced by a few nights under 3°C. Older plants require several weeks of low temperatures.

Like all *Brassica* species *Brassica rapa* has a strong taproot and an extensive finely branched root system, primarily rooting in the top 40 cm of soil. In the generative stage the root system becomes much more extensive. The plants are cross-pollinated by insects such as honeybees. After fertilization, the slender fruits develop rapidly and reach full length some 3 weeks later and are ready for harvest after another 2 weeks.

Ecology Caisin, pakchoi and a limited number of cultivars of Chinese cabbage are normally grown at low elevations in the tropics. Turnip and most cultivars of Chinese cabbage perform better in tropical highlands, above 800 m altitude. High temperatures can cause 'tip burn' and prevent head formation. High day and low night temperatures promote heading. Some turnip and caisin cultivars can tolerate light frost. Most cultivars of vegetable turnip are biennial in temperate areas, requiring a cold induction for bolting of about 6 weeks below 10°C. This condition can be met in East Africa above 2000 m, but in most cases the seed is imported. Caisin can be grown year round for its leaves and tender young inflorescences in subtropical and tropical regions, indicating that flower induction is not influenced by temperature, but there is a tendency towards faster bolting during long days. *Brassica rapa* plants have a high water requirement, but do not tolerate flooding. They prefer a well-drained fertile clay-loam soil with a pH of 5.5–6.5. A high level of organic matter will benefit the plants and balance the availability of essential elements. Plants are sensitive to salinity.

In East and southern Africa *Brassica rapa*

occurs locally as a weed on waste places and along roads at 1500–3000 m altitude.

Propagation and planting Seed production of *Brassica rapa* is normally done outside the lowland humid tropics. Vernalization is easier and plants tend to bolt faster under cooler and longer days. Early bolting reduces the duration and cost of a seed crop. Also, many diseases occurring in the (humid) tropics cause fewer problems in cooler seed production areas. Dry seeds (less than 7% moisture content) can be stored at 20°C for at least 5 years without loss of viability. For open-pollinated cultivars of Chinese cabbage, caisin and pakchoi, seed yields of 1500 kg/ha can be achieved, and hybrids can yield 600–700 kg/ha. Decapitation of newly bolted plants stimulates the development of axillary buds and increases seed yield. For hybrid seed production, a male sterile or self-incompatible female parent is used. Commercial seed is graded for good and uniform germination. On average larger seeds give faster germination and more vigorous seedlings.

Before sowing seed may be treated with hot water or a chemical such as thiram or hypochlorite to prevent seedborne diseases. Plants can be direct seeded (sowing depth 6 mm), raised in densely sown seedbeds or raised in pots or trays for transplanting to the field. For plants raised in seedbeds or trays, water soluble fertilizer (75 ppm, NPK 20–20–20) can best be added to the irrigation water given in the early morning. In the early stage seedlings may require light shading. Hybrids (mainly of Chinese cabbage) are transplanted due to the much higher seed cost. For Chinese cabbage the 1000-seed weight is 2–4.5 g and seed requirement 300–600 g/ha if transplanted and up to 5 times as much if directly sown. Plant density depends strongly on the cultivar grown and planting method used, but is usually 60,000–80,000 plants/ha. Seedlings are transplanted 20–30 days after sowing, in the late afternoon, and in rows 30–50 cm apart and 50 cm between rows. Planting holes may be treated with fungicides before transplanting to prevent damping off.

Caisin and pakchoi are normally direct sown into the field in rows 20 cm apart or broadcast on raised beds. The 1000-seed weight is 2 g and the seed requirement 6–10 kg/ha. Seeds are covered with a thin layer of soil, rice straw or husk, and kept moist. Plants are thinned to 1 plant per 10 cm after about two weeks. In the first 2–3 weeks regular weeding is needed. If raised in seedbeds or trays, plants can be transplanted about 15–20 days after sowing.

Turnip is thinly sown in drills 30 cm apart; the seedlings are thinned to 15 cm apart in the row.

Management The plants are grown on ridges or raised beds. Beds can be mulched with straw or plastic to reduce weed growth and retain moisture in the soil. The soil should be fine and well manured (20–50 t/ha). Good drainage especially during the rainy season is essential. The first 3–4 weeks the crop needs regular weeding. The mineral uptake is rather high. A *Brassica rapa* crop yielding 25 t/ha requires per ha 150–200 kg N, 15–20 kg P and 100–150 kg K. For a correct fertilizer use, soil analyses are essential, combined with crop and cultivar requirements. Fertilizer is normally given in a few steps. It is advised to give 3.5 kg/ha of boron (Borax) before planting. Asian growers give fast-growing crops foliar fertilizer including calcium and boron once a week. Crops in the tropics often suffer from lack of micronutrients resulting in yield loss and increased disease incidence. Watering should be done as required to keep the rooting zone at 65–85% field capacity. Gradual dosage of water and nutrients as in modern cultivation (driptape, drippers, sprinklers) will increase yield and can reduce the spread of diseases with the irrigation water. In seed production it is important to supply sufficient boron (up to 10 kg/ha).

Diseases and pests Many diseases attack *Brassica rapa* in tropical areas. Grey leaf mould (*Alternaria brassicae, Alternaria circinans*) and downy mildew (*Peronospora parasitica*) can be controlled by fungicides and growing tolerant cultivars. Anthracnose (*Colletotrichum higginsianum*) is a serious leaf disease of *Brassica* species, e.g. in Côte d'Ivoire. Bacterial soft rot (*Erwinia carotovora*) occurs under hot humid conditions; its incidence can be reduced by increasing soil pH (liming). Storage rots caused by *Erwinia* can be controlled by alum powder. Black rot (*Xanthomonas campestris* pv. *campestris*) can be controlled by the use of disease-free seeds and seedlings, by planting cultivars with a high level of tolerance and by avoiding overhead irrigation. Club root (*Plasmodiophora brassicae*) has been spreading fast during recent decades and has become a detrimental disease in African highland areas. It is often introduced with soil on roots of transplants from other infested areas and can spread rapidly with irrigation water. Once it is established it can only be eradicated by grow-

ing non-host (non-*Brassica*) crops for at least five years. Damage can be reduced by wide crop rotation, eradication of cruciferous weeds (alternative hosts), by liming and avoiding cultivation on soils with pH < 6.5; a new control method is adding antagonistic soil fungi (*Trichoderma, Mortierella* spp.). A few cultivars of Chinese cabbage appear to have some resistance to some races of the pathogen, but high levels of durable resistance are not yet available. Other noxious fungal diseases are ringspot (*Mycosphaerella brassicicola*) and cabbage yellows (*Fusarium oxysporum*), which can be controlled by crop rotation and resistant cultivars. Cauliflower mosaic virus (CaMV) and turnip mosaic virus (TuMV) can be prevented by control of the aphid vectors and by eradicating hosts like weedy *Brassica* species.
The most important pest of *Brassica rapa* is diamondback moth (*Plutella xylostella*) of which chemical control is increasingly ineffective because of the quick build-up of resistance to all except neem-based insecticides, whereas biological control with sex pheromones and parasitoids (*Diadegma semiclausum, Apanteles plutellae, Diadromus collaris* and *Oomyzus sokolowski*) is promising. Other insect pests are leaf webber (*Crocidolomia binotalis*), web worm (*Hellula undalis*) particularly in southern Africa, cut worm (*Spodoptera littoralis*), flea beetle (*Phyllotreta* spp.) and cabbage butterfly (*Pieris canidia*). The cabbage aphid (*Brevicoryne brassicae*) is vector of mosaic viruses; spraying is advised if more than two percent of plants are infested with aphids.

Harvesting Leafy vegetables are best harvested early in the morning. Chinese cabbage heads are harvested when compact and firm, 40–75 days after sowing (tropical cultivars after 40–55 days). The plant is cut at the base, keeping the head intact. A few outer leaves are sometimes kept for protection during transport. Hybrids can be harvested once over, but heads of open-pollinated cultivars are checked for maturity and harvested in a few rounds. Pakchoi may be harvested as early as 3 weeks after sowing, but is usually harvested 30–45 days after sowing. Plants left in the field too long lose quality fast due to soft rot or bolting. Caisin is harvested just before the flowers open or at the maximum size of the plant just before bolting starts, generally 30–80 days after sowing. In the lowland cultivars are normally harvested several times during a period of 30–45 days after sowing. Late-bolting caisin hybrids are suitable for once-over harvesting. Plants are uprooted or cut at the base and packed in small bundles.
Turnip can be harvested after 35 days for the earliest hybrids, after up to 80 days for later types. Depending on the cultivar, the swollen taproot is 5–10 cm in diameter when ready. It is separated from the leaves (topped) or packed and sold in bundles. In older plants, quality and taste of the turnip deteriorates fast.
In seed production, plants are severed at the base when a noticeable proportion (about 80%) of the fruits have turned orange-brown; the fruits should not yet split when rubbed between the hands. Plants are bundled and hung on a pole for after-ripening and drying for one week. Then the fruits are threshed and sieved with 1.3–3.0 mm sieves, and the seed is dried in the sun. Healthy fully sun-dried seed (12% moisture content) should sink in water.

Yield The yield of Chinese cabbage varies widely according to crop and maturity period, 30–50 t/ha of fresh product being the range for well-grown crops. Caisin can yield 20–45 t/ha in intensive cultivation. Highest yields can be achieved in very dense fields with large nitrogen applications. Pakchoi yields 10–30 t/ha depending on cultivar and time of harvest. Turnip yields 12–25 t/ha in the United States. Normally the swollen taproot is no more than 30% of the total weight of the plant.

Handling after harvest Under ambient conditions harvested Chinese cabbage, caisin and pakchoi plants have a very limited shelf life. The produce should reach the markets on the second day after harvesting at the latest. In some cases the outer leaves of the head can be peeled off and the head still be sold after 2–3 days. Storage on ice may cause chilling injury. Chinese cabbage heads can be stored for 3–6 months at 0°C without freezing and 98–100% relative humidity. The heads of some cultivars are chilling sensitive and should be stored at slightly higher temperatures. Storage in perforated polyethylene bags can extend shelf life, as can storing the heads upside down. In general, plants grown during cooler weather and plants with firmer heads store better. Harvested caisin plants can best be stored at 0–5°C at 95% relative humidity. Because of its general tenderness, it is not suited to pickling or other post-harvest processing. Turnip is not sensitive to chilling injury and can be stored for 4–5 months at 0°C at 90–95% relative humidity. During cooling, the temperature should be reduced gradually to prevent cracking. Turnip is also pickled and slices are

deep frozen or dried.

Genetic resources The largest variation in Chinese cabbage, pakchoi and caisin is found in China. The tendency is for the many landraces to be replaced by a few improved cultivars. The collection of African landraces of Chinese cabbage, e.g. farm-saved seed of old introductions in Cameroon and Congo, might be of interest for future breeding. Many cultivars of turnip can be found in Europe and Japan. The Chinese Academy of Agricultural Sciences (CAAS) at Beijing, the Asian Vegetable Research and Development Center (AVRDC) in Taiwan, the Institute of Horticultural Research at Wellesbourne, United Kingdom, the United States Department of Agriculture (USDA) and the National Institute of Agrobiological Research at Tsubaka, Japan hold large *Brassica rapa* collections.

Breeding Breeding of Chinese cabbage has received much attention from AVRDC (Taiwan) and from Asian seed companies. In the tropics, breeding is limited by difficult vernalization at ambient temperatures. If flowering can be induced in the field, plants are bagged for controlled pollination. If flowering has to be induced artificially, plants are dug out and vernalized in cold rooms. Part of the head may be cut to make bolting easier. *Brassica rapa* plants show inbreeding depression and clear heterosis in hybrids. F_1 hybrid breeding using self-incompatibility started in the 1950s. Both genetic and cytoplasmatic male sterility occur naturally in *Brassica* species. Cytoplasmatic male sterility is now widely used to produce hybrids, systems based on genetic male sterility being impractical and costly. Anther microspore culture is used for the fast creation of completely homozygous lines. The breeding efforts resulted in early producing F_1 hybrid cultivars for tropical lowland conditions, that combine medium firm heads with heat tolerance and resistance to major diseases (soft rot, anthracnose, downy mildew, leaf spot, viruses). In caisin, hybrids are still of lesser importance, the advantages over open-pollinated cultivars being minor. Many improved cultivars are sold in large quantities in South-East Asia and southern China. Several breeding companies (Japan, China, Taiwan, Thailand) have small breeding programmes offering a wide variety of plant types. Some seed traders in Hong Kong offer good open-pollinated selections especially in the early bolting types. East-West Seed Company is the leading supplier of the late bolting type ('Tosakan') used in South-East Asia.

Pakchoi breeding is concentrated in Japan and China, and improved open-pollinated and hybrid cultivars are offered. Mushashino Seed is a leading supplier of tropical hybrids. Turnip breeding is mainly done by European and Japanese seed companies and many cultivars are available, but none are especially adapted to tropical conditions. *Brassica rapa* breeding programmes especially for tropical Africa have not yet been reported, the activities being limited to cultivar testing of Asian and European introductions.

Prospects In tropical Africa the only important *Brassica rapa* crop is Chinese cabbage and interest in it is increasing. Research on its breeding and agronomy for African conditions merits attention. Pakchoi and caisin are productive tropical leafy vegetables with an excellent nutritional value; they are relatively easy to grow and worth promotion. Turnip is less adapted to the tropics and not easy to grow, and is likely to remain a minor vegetable in Africa.

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Sources of illustration Kuo, C.G. & Toxopeus, H., 1993; Opeña, R.T. & Tay, D.C.S., 1993; Tay, D.C.S. & Toxopeus, H., 1993; Toxopeus, H., 1993.

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CANAVALIA GLADIATA (Jacq.) DC.

Protologue Prodr. 2: 404 (1825).

Family Papilionaceae (Leguminosae - Papilionoideae, Fabaceae)

Chromosome number $2n = 22, 44$

Vernacular names Sword bean, sword jackbean, Japanese jackbean (En). Pois sabre, pois sabre rouge, haricot sabre (Fr). Fava-contra (Po). Mwingasiafu, mbwanda (Sw).

Origin and geographic distribution Sword bean is only known cultivated and naturalized. Its origin is in the Old World tropics and it was

Canavalia gladiata – planted

probably domesticated in eastern Asia. The wide dispersal in historic times is thought to be partly due to carrying the remarkable seeds as curios.

Uses In Madagascar the young green fruits and immature seeds of sword bean are used as a cooked vegetable. Sword bean is eaten in Tanzania, where the Swahili expression 'eating sword bean' means 'being happy'. Use of the fruits and immature seeds is also reported from Sri Lanka, India, Indonesia, China, Korea and Japan. Sword bean is further planted as a forage and cover crop. The ripe seeds can be eaten after cooking, but only after removing the seed-coat and several changes of water. The seed is used as feed for cattle and chicken, but if eaten in considerable quantity dry seeds may cause poisoning. Sword bean is grown as an ornamental climber on fences and houses.

Urease is extracted from the seed; it is used in clinical laboratories for the in-vitro determination of urea in human blood. In Korea it is used in the treatment of vomiting, abdominal dropsy, kidney-related lumbago, asthma, obesity, stomach-ache, dysentery, coughs, headache, intercostal neuralgia, epilepsy, schizophrenia, inflammatory diseases and swellings. In Japan it is effective in treating ozena, haemorrhoids, pyorrhea, otitis media, boils and cancers, all kinds of inflammatory diseases and atopic dermatitis. In Korea soap is marketed based on extracts of sword bean; it is used for the treatment of athlete's foot and acne.

Production and international trade No information is available on the trade of sword bean as a vegetable. Seeds of *Canavalia* are traded internationally for the production of urease, but quantities of seed entering the international market are not known.

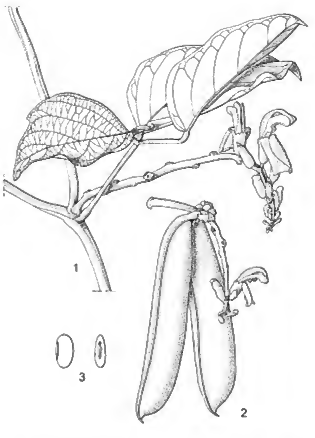
Properties The nutritional composition of fresh sword bean fruits per 100 g edible portion is: water 83.6 g, energy 247 kJ (59 kcal), protein 4.6 g, fat 0.4 g, carbohydrate 10.7 g, fibre 2.6 g, Ca 33 mg, P 66 mg, Fe 1.2 mg, vitamin A 40 IU, thiamin 0.2 mg, riboflavin 0.1 mg, niacin 2 mg, ascorbic acid 32 mg. Dry seeds contain per 100 g: water 10.7 g, energy 1453 kJ (347 kcal), protein 24.5 g, fat 2.6 g, carbohydrate 59 g, fibre 7.4 g, Ca 158 mg, P 298 mg, Fe 7.0 mg, thiamin 0.8 mg, riboflavin 1.8 mg, ascorbic acid 1 mg (Rubatzky, V.E. & Yamaguchi, M., 1997). The seed protein is poor in methionine, but rich in lysine.

The seeds of *Canavalia* species contain several growth-inhibiting and toxic storage proteins, e.g. canavalin (vicilin), con-canavalin A and B and canatoxin. The urease contained in the seed is chemically related to canatoxin. It also contains the toxic non-protein amino acid canavanine, a structural analogue of L-arginine. In both human and animal nutrition dry seeds have the shortcoming that their proteins have a low digestibility and a low biological value, and raw seeds are poisonous in large quantities. The digestibility can be improved by treatment such as heating (prolonged cooking, pressure-cooking or roasting) or fermenting.

There are numerous publications of results of research into the chemical composition of several *Canavalia* species. Seed protein content and composition of *Canavalia gladiata* and *Canavalia ensiformis* (L.) DC. are similar.

Adulterations and substitutes Alternative sources of urease are various bacteria (e.g. *Klebsiella aerogenes*), fungi (e.g. *Coccidioides immitis*) and higher plants (e.g. soya bean).

Description Perennial trailing or climbing herb up to 10 m long, often grown as an annual; root system deep. Leaves alternate, pinnately 3-foliolate; stipules small, deciduous; petiole 5–17 cm long; leaflets with 4–7 mm long stalks, ovate, 7.5–20 cm × 5–14 cm, apex acuminate, shortly pubescent on both sides. Inflorescence an axillary raceme 7–12 cm long; peduncle 4–20 cm long. Flowers bisexual, papilionaceous, often resupinate; calyx up to 1.5 cm long, 2-lipped with a large 2-fid upper lip and a much smaller 3-fid lower lip; corolla white, standard c. 3.5 cm long; stamens 10, all joined; ovary superior, style slender, curved, stigma small. Fruit a linear-oblong pod, slightly compressed, sometimes curved, 20–40(–60) cm × 3.5–5 cm, widest near the apex, 8–16-seeded,



Canavalia gladiata – *1, part of flowering stem; 2, inflorescence with young fruits; 3, seeds. Source: PROSEA*

spirally dehiscent; each valve with ventral rib and extra rib spaced c. 4 mm. Seeds 2–3.5 cm × 1.5–2 cm, red or red-brown, rarely black, pink or white; hilum 1.5–2.0 cm long. Seedling with epigeal germination; first 2 leaves simple, opposite, with stipules connate.

Other botanical information *Canavalia* comprises about 60 species, most of these of American origin. There are many reports in the literature of the occurrence of the sword bean in tropical Africa, but there are few herbarium specimens from Africa. Many of the reports likely refer to the widespread indigenous *Canavalia africana* Dunn (synonym: *Canavalia virosa* auct. non (Roxb.) Wight & Arn.). In the interior of tropical Africa at higher altitudes (over 300 m) *Canavalia africana* is the most common indigenous *Canavalia* species. It is occasionally cultivated as a cover crop and green manure. The seeds are eaten in Ethiopia and Tanzania, but often only as a famine food. In Tanzania the leaves are used in a recipe for treating smallpox. In India, where *Canavalia africana* occurs as well, researchers have named plants collected in the wild *Canavalia gladiata*. Jackbean (*Canavalia ensiformis*) is considered a native of the New World and is only known in cultivation. It is widely grown in Africa but mainly as a cover crop, forage, green manure and ornamental. The use of its fruits and immature seeds seems fairly common in Asia but substantiated reports of use as a vegetable in Africa are lacking. The 3 abovementioned taxa are considered by some as a single species as they cross freely and their uses and chemical composition are similar. Also, an analysis based on DNA data designed to distinguish legume species failed to find differences between *Canavalia ensiformis* and *Canavalia gladiata*. However most floras separate the 3 species as follows:

Canavalia gladiata: standard c. 3.5 cm long, white; fruit 20–40(–60) cm × 3.5–5 cm; seeds red or red-brown, rarely white, 2–3.5 cm long, hilum 1.5–2 cm long.

Canavalia ensiformis: standard c. 2.5 cm long, pink to purple; fruit 15–35 cm × 3–3.5 cm; seeds ivory or white, 1.5–2 cm long, hilum 0.5–1 cm long.

Canavalia africana: standard c. 3 cm long, white with mauve veins; fruit 10–17 cm × 2.5–3 cm; seeds brown or red-brown, 1.5–2 cm long, hilum 1–1.5 cm long.

Cultivars of *Canavalia ensiformis* vary widely, particularly in the degree of twining, the size of the fruits and the number and colour of the seeds.

Growth and development Sword bean seed germinates readily and the plant is relatively fast growing. Flowers are pollinated by insects and 20% or more cross-pollination occurs.

Ecology Sword bean requires temperatures of 20–30°C and is cultivated from sea-level up to 1000 m altitude. It is tolerant of drought once established and also tolerant of waterlogging, shade and salinity, making it one of the most hardy tropical legumes. It prefers an evenly distributed annual rainfall of 900–1500 mm. It grows well even on nutrient depleted soils and on acid soils, even with a pH as low as 4.5.

Propagation and planting Sword bean is usually grown by smallholder farmers near houses and allowed to climb on walls, fences and trees. Seeds are sown at a depth of 5–7.5 cm. As a field crop, it is usually sown at a spacing of 75–90 cm between rows and 45–60 cm within the row, at a seed rate of 25–40 kg/ha.

Management To avoid a build up of pests and diseases it is recommended that sword

bean be treated as an annual crop or retained at most for 2 years.

Diseases and pests Sword bean is fairly resistant to diseases and pests. The most serious fungal disease is root rot caused by *Colletotrichum lindemuthianum*. Sword bean is a host of tomato spotted wilt virus (TSWV). *Canavalia* is known to reduce nematode populations. However, it is susceptible to the soybean cyst nematode (*Heterodera glycines*) that has not yet been recorded in Africa. Major pests are fall army worm (*Spodoptera frugiperda*) and beetle grubs that bore into the stems. Sword bean seeds are fairly resistant to storage pests.

Harvesting Young sword bean fruits can be harvested from 3–4 months after sowing when they are 10–15 cm long, before they swell and become fibrous and tough. Mature seed can be harvested after 5–10 months. As the fruits shatter their seeds when ripe, harvesting should be done timely.

Yield Yields of green fruits can be up to 4 t/ha. Forage yields of up to 60 t/ha have been reported. Seed yields of up to 5.4 t/ha are possible, but a seed yield of 1.5 t/ha is more common.

Genetic resources Worldwide collection of *Canavalia* germplasm is urgently needed. Small germplasm collections of *Canavalia* are maintained at the Australian Tropical Crops & Forages Genetic Resources Centre, Biloela, Queensland. A few accessions are available in Ethiopia (ILRI), Nigeria (IITA), South Africa, Brazil, China, Colombia and India.

Breeding Sword bean is not known from the wild and must have undergone selection during centuries. Selection has favoured increased pod and seed size but has not resulted in a reduction in biochemical toxins. This would be consistent with selection for use as fodder or as a green fruit vegetable rather than as a pulse crop. Breeding is difficult as the flowers are very sensitive to damage during emasculation and emasculated flowers usually abscise; therefore bud pollination is recommended. In South-East Asia sword bean cultivars have been developed with reduced toxicity. Hybrids of *Canavalia gladiata* with both *Canavalia africana* and *Canavalia ensiformis* have occurred from natural crosses. Breeding programmes should use this wide base of germplasm.

Prospects To increase the use of *Canavalia* green fruits and young seeds as a vegetable in tropical Africa, improved cultivars should be made available either by introducing Asian cultivars or by breeding. Major limitations for increased use of the dry seeds of *Canavalia* in human nutrition are the poor taste, the unappealing texture and antinutritional factors that make laborious preparation necessary. In these respects *Canavalia* faces the same acceptability problems in Africa as soya bean. However, as *Canavalia* is a very tough and resilient crop it could play a larger role if seeds were produced in quantity and processed on an industrial scale. Breeding and selection could play a role in developing cultivars with reduced toxicity. Sword bean will remain important as a green manure and cover crop and as fodder. A critical review of the taxonomy of the genus *Canavalia* is overdue.

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Authors C.H. Bosch

Based on PROSEA 8: Vegetables.

CAPSICUM ANNUUM L.

Protologue Sp. pl. 1: 188 (1753).

Family Solanaceae

Chromosome number $2n = 24$

Synonyms *Capsicum frutescens* L. (1753), *Capsicum chinense* Jacq. (1776).

Vernacular names Capsicum, capsicum pepper; chilli, sweet pepper, bell pepper; bird pepper; chinense pepper, aromatic pepper, bonnet pepper (En). Piment; poivron, paprika; piment oiseau ; poivre de Cayenne; habanero, piment antillais (Fr). Pimentos; pimentão, pimento doce; jindungu, pimento, piri-piri, pimento de caiena; pimento chinês (Po). Mpilipili, mpilipili hoho (Sw).

Origin and geographic distribution The ge-

Capsicum annuum – planted

nus *Capsicum* originated in Central and South America. The approximately 25 wild species all occur in this area. The cultivated forms were domesticated in prehistoric times; the main difference with the wild types is that the fruits are not easily dehiscent and hence less damaged by birds. Mexico was probably the centre of origin of the chilli and sweet pepper (*Capsicum annuum* in the narrow sense), while aromatic hot pepper (*Capsicum chinense*) originated in the Amazonian region and bird pepper (*Capsicum frutescens*) in the coastal regions of the southern part of tropical South America. In cultivation the 3 species have been crossed intensively and many intermediate forms occur. They are therefore treated here as one broad group of cultivars, although characteristic examples of the 3 original species can still be recognized. Shortly after Columbus' discovery of America, the Spanish and Portuguese brought capsicum pepper (hot and sweet) to Europe, from where especially the hot pepper was widely dispersed to all tropical and subtropical areas of the world. By the end of the 17th century it was grown as a popular vegetable and spice everywhere in the tropics and many very distinct types and landraces had been developed. The aromatic hot pepper was probably introduced in West Africa during a later period than the chilli and bird pepper, and African slaves brought it back from West Africa to the Caribbean and West Indies.

Capsicum annuum is cultivated so widely in Africa that African people consider hot pepper as a traditional African vegetable or spice, while the much less popular sweet pepper is seen as an exotic, newly introduced European vegetable. Sweet pepper, one of the most important glasshouse and summer vegetables in Western industrialised countries, is more adapted to temperate climates than hot pepper. Some hot pepper cultivars, including aromatic hot pepper, are adapted to a temperate climate, but the growth of bird pepper is too slow for outdoor cultivation in a temperate climate.

Two other domesticated species, *Capsicum baccatum* L. (aji) and *Capsicum pubescens* Ruiz & Pav. (rocoto), are commonly cultivated in Latin America. Commercial cultivars of *Capsicum baccatum* are occasionally found in Asian countries, whereas adapted cultivars of the rather cold-resistant *Capsicum pubescens* are extensively cultivated in highland regions of Java (Indonesia), but neither species has been recorded for Africa.

Uses Capsicum fruits are consumed in fresh, dried or processed form. Non-pungent fruits, usually called sweet pepper, are eaten raw in salads, but more commonly cooked, fried or processed together with other foods. They are consumed in such quantity per serving that they constitute a real table vegetable contributing to the nutritional value of the meal. The most pungent types, including chillies, bird pepper and aromatic hot pepper, are consumed in very small quantities and are considered a condiment or spice for seasoning and stimulating appetite. As many intermediate forms exist, there is no strict borderline between the use of capsicum as spice and vegetable. Hot pepper is processed into ketchup or spice mixtures for flavouring all kinds of food. In Ethiopia dried hot pepper is a component of a mixed spice powder. Hot peppers are extensively pickled in salt and vinegar. In some regions (e.g. Sudan) they are used to make hot fresh sauces by crushing the green immature fruits or cutting them into small pieces and mix them with lime juice, salt and peanut butter. They are used industrially as an ingredient of many products, e.g. hot sauces, canned fish, ginger beer, as well as for some pharmaceutical products. In some regions (e.g. Gabon) shoot tips and young leaves are eaten as a vegetable. The red pigment extracted from ripe fruits is used as a natural colouring agent for food and cosmetics.

Hot pepper is widely used in local medicine. Pungent peppers cause strong salivation, aid digestion and are laxative. Capsaicin, the active ingredient, stimulates the mucous membrane of the mouth, stomach and bowels, causing strong peristalsis. Another effect is sweat-

ing of the body, which is a relief in hot climates as it has a cooling effect. It also causes tingling of the tongue and cheeks and secretion of nose, eyes and sinuses. People suffering from a flu experience relief by consuming hot pepper. It is said that regular consumption is beneficial for vascular conditions and against haemorrhoids, varicose veins, anorexia and liver congestion. An infusion of mature fruits is said to stop vomiting, and is used to treat dysentery, fever and yaws. In Ethiopia people consume hot pepper with raw meat, believing that the hot pepper kills dangerous pathogens. Hot pepper has often been ascribed antibiotic properties. It is recommended for people suffering from amoeba infection and intestinal worms. In pure or processed form it is applied externally as a rubefacient and analgesic in cases of back-pain, rheumatism, articular and muscular pains and swollen feet, and antidote in cases of poisoning. The leaves are used as a dressing for wounds and sores, and the leaf sap is squeezed into the eyes against headache (Ghana, Congo). The leaves are prepared as a potion to treat coughs and heart-pain. In East Africa the leaves are externally used against bubonic plague. In Gabon a leaf macerate with lemon juice is dropped into weeping ears. In Guinea a mixture including red pepper powder is used as a traditional insecticide to control kola weevil. Especially in Western countries bushy erect capsicum types with many small red or yellow fruits are popular as ornamental potplants. In recent years hot pepper is increasingly used in aerosol sprays replacing tear gas, for personal defence of police officials. Bird peppers specifically grown for this purpose in Kenya and Tanzania are exported in powder form to the United States.

Production and international trade FAO statistics estimate world production of capsicum peppers in 2001 at 21.3 million t from a harvested area of 1.6 million ha (average yield 13.4 t/ha); China is the largest producer with 10 million t, followed by Mexico (1.9 million t) and Turkey (1.5 million t). India is probably erroneously represented with only 50,000 t. Production in tropical Africa is estimated at 1 million t, with Nigeria (715,000 t from 90,000 ha) and Ghana (270,000 t from 75,000 ha) as the largest producers. The FAO statistics, however, are incomplete or unreliable for African countries; production from intercropping and home gardens is often not included. Data are presented for only 13 out of the 47 countries of tropical Africa.

Hot peppers, fresh, dried or processed, are an important product in all local markets in Africa, more so in West Africa than in East Africa. In West Africa aromatic hot pepper (*Capsicum chinense*) is very popular, especially the most aromatic and less pungent cultivars. International trading of fresh or dried hot pepper occasionally occurs, but few data are available. Export from Africa (mainly dried hot pepper) is very limited, e.g. Ethiopia exports to Europe and the Middle East, Nigeria to the United Kingdom, Senegal to France. Ethiopia, Malawi, Zambia and Zimbabwe export oleoresin capsicum (pungent) and oleoresin paprika (not pungent) as food additives and colouring. Fresh hot pepper (mainly aromatic hot pepper) is exported from Uganda and West Africa to Europe (Paris, London, Brussels), mainly during winter months.

The cultivated area of sweet pepper in Africa is much smaller than that of hot pepper. Sweet pepper is becoming increasingly popular as an exotic vegetable, traded through supermarkets. Some sweet pepper is produced in Senegal and Côte d'Ivoire for export to France.

Properties The approximate composition of fresh hot peppers per 100 g edible portion is: water 74 g, energy 395 kJ (94 kcal), protein 4.1 g, fat 2.3 g, carbohydrate 18 g, fibre 6.0 g, Ca 58 mg, P 101 mg, Fe 2.9 mg, β-carotene 7,140 μg, thiamin 0.25 mg, riboflavin 0.20 mg, niacin 2.4 mg and ascorbic acid 121 mg. The composition of dried hot peppers is given as: water 10 g, energy 1453 kJ (346 kcal), protein 12.5 g, fat 11.5 g, carbohydrate 61.5 g, fibre 23.3 g, Ca 187 mg, P 330 mg, Fe 16.7 mg, β-carotene 14,300 μg, thiamin 0.38 mg, riboflavin 0.68 mg, niacin 7.2 mg and ascorbic acid 12 mg. Fresh green sweet peppers contain per 100 g edible portion: water 86 g, energy 202 kJ (48 kcal), protein 2.0 g, fat 0.8 g, carbohydrate 10.3 g, fibre 2.6 g, Ca 29 mg, P 61 mg, Fe 2.6 mg, β-carotene 180 μg (red, mature fruits 2,760 μg), thiamin 0.12 mg, riboflavin 0.15 mg, niacin 2.2 mg and ascorbic acid 140 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). The content of ascorbic acid (vitamin C) in fresh capsicum and of vitamin A in mature red capsicum peppers is very high. Drying causes a considerable loss of carotene and thiamin, whereas vitamin C disappears almost completely. Differences in cultivar or in ecological and cultural conditions, harvest stage and post-harvest handling are responsible for a large variation in moisture content and chemical composition.

The pungent principle of hot pepper is capsai-

cin, a complex of capsaicinoid alkaloids found in variable quantities (0.01–1.0% of dry weight) concentrated in the placental tissue and cross-walls of the fruits, but in very pungent types in all fleshy parts. Capsaicin ($C_{18}H_{27}NO_3$) is odourless, colourless and flavourless. The heat sensation results from irritation of pain receptor cells and differs between individual persons. The content of capsaicinoids can be determined chemically, but in practice (e.g. for testing varieties or differences between samples) the organoleptic method is more practical, using a dilution of one part per million. Referring to pungency three main categories of capsicum fruits are distinguished: (1) non-pungent sweet peppers, (2) moderately pungent or 'normal' hot peppers, and (3) very pungent hot pepper types, mostly bird pepper and aromatic hot pepper. However, several cultivars are intermediate. Taste and flavour of peppers depend on other compounds. Glucose and fructose sugars give the sweetness to sweet pepper. A volatile compound, 2-methoxy-3-isobutyl-pyrazine ($C_9H_{14}N_2O$), causes the typical taste and smell of sweet pepper. Capsicum fruits contain more than 100 compounds contributing to flavour and aroma. The flavour of the aromatic hot pepper is quite different from common hot pepper or bird pepper. Mature fruits are rich in pigments such as carotenoids and xanthophylls, the major pigment being the carotenoids called capsanthin ($C_{40}H_{56}O_3$) and capsorubin ($C_{40}H_{56}O_4$)(E 160c).
Capsaicin showed anti-oxidant, antimutagenic, anticarcinogenic and immunosuppressive activities. It also inhibits bacterial growth and platelet aggregation. Hypocholesterolaemic effects have been recorded for the oleoresin. In a double-blind, placebo-controlled clinical test using 30 patients with functional dyspepsia capsicum powder was effective in decreasing the intensity of dyspeptic symptoms, capsaicin being the active ingredient.
The weight of seed, largely depending on cultivar, may be considerable, normally 10–20% of the dry weight of the fruit. The smaller the fruit, the higher the weight percentage of seed, reaching 50% in small dried hot peppers. The seed contains 12–25% oil, mainly composed of linoleic acid, an unsaturated fatty acid, and further mainly of carbohydrates, proteins and fibre.

Adulterations and substitutes As a spice, hot pepper may be replaced by *Aframomum melegueta* (Roscoe) K.Schum.

Description Erect herb or subshrub, up to 2.5 m tall, much-branched, grown as an annual but in home gardens sometimes a short-term perennial; taproot strong, lateral roots numerous; stem irregularly angular to subterete, up to 1 cm in diameter, green to brown-green, often softly hairy and with purplish spots near nodes. Leaves alternate, simple, very variable; stipules absent; petiole up to 10 cm long; blade ovate, up to 10(–16) cm × 5(–8) cm, acuminate at apex, margin usually entire, almost glabrous, pale to dark green. Flowers usually solitary, sometimes 2 or more per node, terminal, bisexual, usually 5-merous; pedicel up to 3 cm long, but elongating up to 8 cm in fruit, usually pending; calyx cup-shaped, persistent and enlarging in fruit, usually with conspicuous teeth; corolla campanulate to rotate, 8–15 mm in diameter, white or greenish, rarely purple, tube short, lobes ovate; stamens adnate at base to corolla tube, with pale blue to purplish anthers; ovary superior, 2(–4)-celled, style filiform, white or purplish, stigma capitate. Fruit a berry, very variable in size, shape, colour, and degree of pungency, usually more or less conical, up to 30 cm long, green, yellow, cream

Capsicum annuum – 1, habit of chilli plant; 2, shoot of bird pepper plant; 3, fruit of sweet pepper; 4, fruit of aromatic pepper.
Source: PROSEA

or purplish when immature, red, orange, yellow or brown when mature, many-seeded. Seeds orbicular, flattened, 3–5.5 mm in diameter, pale yellow. Seedling with epigeal germination.

Other botanical information *Capsicum annuum*, *Capsicum frutescens* and *Capsicum chinense* are mostly considered as three different species, based on a combination of fruit and flower characters. They are, however, closely related and it is doubtful whether the distinction is taxonomically justified as it is based on only a few overlapping morphological characters. Many intermediate forms occur, which are difficult to identify and assign to one of the three. Apparently there has been a gene flow between these taxa, and it is likely that they share a common ancestral gene pool. Also DNA finger printing and gene mapping point to a close relation of the three taxa, with clusters of similar genes within each taxon. A certain degree of crossability under field conditions exists. Cytogenetic studies show aberrant chromosome pairing between *Capsicum chinense* and the two other taxa, yet hand crosses often result in viable and fertile hybrids. At present more and more commercial cultivars are released that have resulted from crosses between these three taxa.

Since for capsicum research in tropical Africa the distinction of *Capsicum annuum*, *Capsicum chinense* and *Capsicum frutescens* on species level is unpractical and unfeasible, they are treated here as belonging to a single species *Capsicum annuum*. They can, however, be distinguished as cultivar-groups. In the past several horticultural cultivar groupings for capsicum based on fruit shapes have been made. These groups are overlapping and refer mainly to the American situation. For tropical Africa the cultivars can be classified in the following 4 types:

- Sweet pepper (also named paprika, bell pepper); fast-growing annual herb, flowers solitary, white, pending, fruits large, 3–12 cm in diameter, inflated, red, orange, yellow, purple, white, blue or brown when mature, with mild, sweet aroma and taste. Sweet pepper is not very common in Africa, but increasingly important in urban markets.
- Chilli (also spelled chili); fast-growing annual herb, flowers solitary, white, pending, fruits variable, but mostly elongate or ovoid, 2–16 cm long, or globose, mostly red, sometimes orange or yellow at maturity, fruit wall smooth or slightly wrinkled, taste mild to very pungent. This is the most common hot pepper type, for fresh consumption or for drying.
- Bird pepper (*Capsicum frutescens*); slow-growing short-term perennial or perennial subshrub, flowers in clusters of 2 or more, waxy greenish white, usually erect, fruits elongate, usually upright, usually small and narrow, up to 5 cm × 1 cm, green to cream or yellow when immature, orange to red when mature, fruit wall smooth, extremely pungent. Bird pepper is very common in fields for home consumption, but it is less popular than chillies as a commercial crop because of high labour costs.
- Aromatic pepper (*Capsicum chinense* also named chinense pepper); fairly slow-growing annual to perennial herb, flowers in clusters of 2 or more, sometimes solitary, waxy greenish (rarely white or purple), usually pending, fruits usually globose to cylindrical, 2–5 cm × 1.5–3 cm, wrinkled, usually pending, red to orange or yellow when mature. Aromatic pepper has a typical flavour and aroma and its pungency can range from extremely hot to very mild. Aromatic hot pepper is fairly common in West Africa, preferred by farmers during the rainy season because it is stronger and more resistant to anthracnose and viruses than chillies.

Most of the numerous African cultivars and landraces can be categorized into these 4 categories, but some are intermediary. Practically all farmers use local cultivars, appropriate for the local market. African countries use their own classification of local cultivars, e.g. the Sudanese classification of the local hot peppers into two groups: 'Gabaniet' with small and very hot fruits, and 'Zalengi' with medium- and big-sized fruits that are usually mildly pungent. Popular chilli cultivars in Ethiopia are 'Santaka', 'Bakolocal' and 'Marekofana', in Nigeria 'Dan Mayere' and 'Dan Tsiga'. Although international cultivars of chillies ('Anaheim'), bird pepper ('Tabasco', 'Cayenne') and aromatic hot pepper ('Habanero', 'Scotch Bonnet') appear in the market, they are less adapted to the ecological and market requirements of African countries. This situation is different for sweet peppers, for which few, if any, African cultivars exist. Farmers use imported seed, mostly F_1 hybrids, from international seed companies. Some well-known cultivars are 'Yolo Wonder', 'California Wonder' and 'Bell Boy'. Farmers growing oleoresin paprika use South African cultivars.

Growth and development Seeds germinate 6–21 days after sowing. Continuous flowering starts 60–90 days after sowing. Flowers open 3 hours after sunrise and are open for 1–3 days. Although normally self-pollinated, 2–90% cross-pollination may occur, depending on activity of bees and thrips collecting nectar and pollen; on average, cross-pollination is about 15%. Certain cultivars show strong heterostyly causing a high level of cross-pollination. In the bud stage the stigma is receptive, but the pollen is not yet mature, so hand pollination is easy. Under normal circumstances 40–50% of the flowers set fruit. Fruits begin to mature 4–5 weeks after flowering, and can be picked every 5–7 days. The peak harvest period is 4–7 months after sowing. In the absence of frost and diseases growth continues and plants may become perennial.

Ecology *Capsicum annuum* is a tropical species, but adapted to cultivation in temperate regions during the summer or, in protected cultivation, year-round. Optimal temperatures for growth and production are between 18°C and 30°C. Seeds germinate best at 25–30°C. Flowering is delayed if day temperatures drop below 25°C. Flower buds abort if night temperatures are too high (above 32°C). Pollen viability is significantly reduced at temperatures above 30°C and below 15°C. Cool nights down to 15°C favour fruit setting. Sweet pepper needs cooler nights and is clearly more adapted to cooler growing conditions than hot peppers. Sweet pepper cultivation is difficult in the hot and humid tropical lowland. Capsicum is day-neutral, but certain forms may show a photoperiodic reaction; long days may slightly delay the first flowering. It tolerates shade up to 45% of solar radiation, although shade may delay flowering. Capsicum grows at a wide range of altitudes, from lowland up to 2000 m, in Ethiopia even up to 3000 m. If not irrigated, an annual rainfall of at least 600 mm is required. Capsicum grows on almost all soil types, but is most suited to well-drained sandy or loamy soils, rich in lime, with a pH of 5.5–6.8 and a high water retention capacity. Severe flooding or drought is injurious. Waterlogging causes poor fruit setting, diseases and fruit rotting. Capsicum is moderately sensitive to soil salinity.

Propagation and planting Seeds should be harvested from mature fruits after some weeks of post-harvest ripening. Seed extraction of pungent peppers is an unpleasant work that can be alleviated by mechanical dust collection. The 1000-seed weight is about 3.3 g for bird pepper to 7 g for types with large fruits. Seed remains viable for 2–3 years without special conservation methods if kept dry at room temperature, but it rapidly loses viability if stored at high temperatures or humidity. Seed dormancy may occur to a limited extent during some months after harvest, especially if seed is harvested from immature fruits. Seed priming treatments are sometimes effective in invigorating germination and are sometimes applied for sweet peppers in Western countries but they are not used in Africa. Storage of primed (pre-germinated) seed is difficult. To plant one ha, 200–800 g of seed is needed, depending on plant density and provided adequate nursery technology is applied. In fact, the better the seed quality and nursery technology, the lower the seed requirement. The extreme is shown by sweet pepper under protected cultivation; growers use only 150 g/ha of expensive hybrid seed. The hot pepper seed used by most African farmers is from own production or is cheap seed of uncertain quality and origin from local seed dealers. The germination capacity being doubtful, farmers use several kg seed per ha.

The seed is sown shallowly in nursery beds or flats, broadcast or in rows 20 cm apart. Direct seeding is rarely practised. Seedbeds should be protected against rain and direct sun. They are usually covered with straw, palm leaves or plastic. For better production, seedlings may be transferred to seedling pots (soil blocks, plastic pots, paper cups, banana leaf-rolls) when the cotyledons are fully expanded. In the nursery, starter fertilizer is recommended at 2-week intervals. Transplants are planted out in the field when they have 8–10 leaves, usually 30–40 days after sowing. Restriction of watering and removal of shade protection, starting a week before transplanting, is recommended to produce hardy transplants. Transplanting should be done during cloudy days or in the late afternoon; when planted in dry soil irrigation should be applied. Capsicum is suitable for intercropping and is then sometimes sown directly in the field. A normal spacing is 50–80 cm between the rows and 20–40 cm in the rows, with densities of 50,000–80,000 plants per ha. In Ethiopia, farmers transplant in beds 1.2 m wide without rows, at a density of 5–15 plants per m^2 with an optimum of 10 plants/m^2. In Mauritius, a spacing of 60 cm × 30 cm (55,000 pl/ha) gave the highest yield (6.2 t/ha); in Zimbabwe, the recommended number of plants per ha is 30,000–55,000 for chillies,

20,000–55,000 for sweet peppers, and 55,000–70,000 for paprika powder production.

Management In Africa capsicum production is usually practised on small-scale farms on plots of 0.1–0.5 ha. If properly managed, it is labour intensive, especially planting, weed control and the repeated harvests. The greatest part of the hot pepper area in tropical Africa, however, is cultivated in an extensive way as a low input system. Capsicum thrives best if supplied with liberal quantities of organic matter supplemented with balanced mineral fertilizers. Nutrient availability is subject to soil type and environmental conditions, so local recommendations for fertilizer application vary greatly. A reasonable recommendation is to supply 10–20 t/ha of organic fertilizer (e.g. manure). General nutrient requirements are 130 kg/ha of N, 80 kg/ha of P and 110 kg/ha of K, split into a basal dressing plus some side dressings at intervals of 3–4 weeks, beginning at first flowering. Boron at the rate of 10 kg/ha is also recommended. Capsicum is very sensitive to blossom-end rot caused by calcium deficiency and irregular irrigation.

Capsicum is grown under rainfed (rainy season) or irrigated (dry season) conditions; it requires at least 600 mm water during its growing period. During flowering and fruit setting it is sensitive to moisture stress, causing flower and fruit dropping, and more than normal pungency of the fruits. Irrigation is needed when plants show wilting in the afternoon.

In Africa, manual weeding is the common practice for weed control. Organic (usually straw) or plastic mulches are also effective. Staking is not common in most of Africa, but may help to minimize lodging and fruit rotting in the rainy season.

Capsicum is often relay-cropped with tomatoes, onions, garlic, okra, *Brassica* species, cucurbits and pulses. It also grows well among newly established perennial crops. To avoid soilborne diseases, capsicum should not be planted after other solanaceous crops.

Protected cultivation using plastic tunnels is rarely used in Africa; it is practised for sweet pepper in the highlands, and at lower elevations on seedbeds as roofing against heavy rains.

Diseases and pests Capsicum suffers from numerous diseases and pests. Many sweet pepper producers in Western countries use integrated pest management (IPM) technology, especially in greenhouses, to keep the crop healthy with a minimum application of toxic chemicals. Many kinds of biological products or natural enemies for the control of capsicum diseases and pests are available, but these are less appropriate for tropical African conditions. Because of the high costs, the majority of the capsicum producers in Africa do not apply chemical spraying. However, the combination of intercropping and refraining from using pesticides maintains a high population density of natural predators of pests and a low infection level. Consequently, crop losses are generally within reasonable proportions. A crop will be more healthy if the farmer uses healthy seed and respects a crop rotation with at least two years without any solanaceous crop to minimize soilborne diseases, applies proper plant spacing for good ventilation against foliar diseases, and good drainage (raised beds in the rainy season). With the intensification of the cropping system, e.g. high doses of fertilizer, the potential yield will rise considerably, but so will the risk of high crop losses. The first control method is to choose a local cultivar with resistance to the most important diseases and pests. However, in tropical African countries improved local cultivars with resistance genes are rarely available. A broad general field tolerance is observed in some landraces.

The most troublesome diseases and pests, reported for tropical Africa, are:

- Virus diseases. Aphid-transmitted viruses are cucumber mosaic virus (CMV), alfalfa mosaic virus (AMV), pepper veinal mottle virus (PVMV), potato virus Y (PVY), pepper mottle virus (PeMV) and a complex of tobamoviruses. Mechanically transmitted viruses are tobacco mosaic virus (TMV) and pepper leaf curl virus (PLCV). Geminiviruses are transmitted by white flies, tomato spotted wilt virus (TSWV) by thrips. Resistance to most viruses occurring in Nigeria was found in local as well as imported hot and sweet pepper accessions; hence prospects for breeding cultivars combining resistance genes are hopeful. Chinense pepper is a source of virus resistance. Reflective aluminium-coated plastic mulches minimize insect vectors (aphids, thrips); this has become common practice in South-East Asia. Mineral oil spraying can be applied against aphids. Several viruses, e.g. TMV, are seedborne; hence the need for healthy seed.
- Fungal diseases. Anthracnose or fruit rot caused by *Colletotrichum gloeosporioides* and –to a lesser degree– *Colletotrichum capsici* is a major problem of ripe fruits especially in

humid lowland, causing crop losses of up to 90%. Proper crop management to minimize the source of inoculum via seeds or host debris is the best control. Local West African aromatic pepper cultivars are fairly resistant. *Cercospora* leaf spot (*Cercospora capsici*) and velvet spot (*Cercospora unamunoi*) may cause complete defoliation. A major problem in the rainy season, affecting all plant parts, is *Phytophthora* blight. It is also called crown rot or basal stem rot and is caused by *Phytophthora capsici*. The Nigerian hot pepper 'U-Kimba' is resistant. Damping off in the seedbed is caused by *Pythium*, *Fusarium* and *Sclerotinia*, wilting by white rot (*Sclerotium rolfsii*) and *Verticillium dahliae*. Powdery mildew (*Leveillula taurica*) is reported from Sudan and East Africa during the cool season. General control methods are the use of healthy seed, seedbed disinfection, good ventilation (not too dense planting), and good soil drainage. Many fungicides are available for chemical control.

- Bacterial diseases. Bacterial wilt (*Ralstonia solanacearum*) causes heavy plant losses. Some sweet pepper cultivars such as the popular 'Yolo Wonder' are very susceptible, other cultivars such as 'Narval' from Guadeloupe are medium resistant. Chillies are less susceptible and aromatic pepper and bird pepper are almost completely resistant. Bacterial wilt is partially controlled by a good drainage, e.g. raised beds during the rainy season. Bacterial spot (*Xanthomonas campestris* pv. *vesicatoria*) is controlled by the use of healthy seed. Other bacterial diseases are bacterial canker (*Corynebacterium michiganense*) and bacterial soft rot (*Erwinia carotovora*).
- Nematodes (*Meloidogyne*, *Xiphinema*). Damage may be avoided by crop rotation with cereals, pulses or vegetables that are not host plants, and the application of much organic manure. Resistance to *Meloidogyne incognita* was found in the aromatic hot pepper cultivar 'Scotch Bonnet'.
- Insects and mites. The mite *Polyphagotarsonemus latus* causes virus-like deformations of leaves and shoot tips. Thrips, the main problem in protected cultivation of sweet pepper, sometimes cause heavy damage in hot pepper fields during the dry season. Irrigation by overhead sprinkling reduces thrip damage. Other pests are caterpillars (*Heliothis*, *Spodoptera*), aphids, whiteflies, fruit flies (*Atherigona orientalis*) and termites (*Microtermes*). Since most of these are polyphagous, control is difficult. Inappropriate pesticides and over-use of pesticides often worsen pest problems, especially by thrips and mites. Control of caterpillars with Bt (*Bacillus thuringiensis*) or neem (*Azadirachta indica* A.Juss.) products spare natural predators.

Harvesting Capsicum peppers are ready for harvest 2–3 months after transplanting, 3–6 weeks after flowering, depending on the fruit maturity desired. Sweet peppers as well as hot peppers are harvested at the green mature stage or at full maturity, depending on demand and utilization. Green harvesting stimulates fruit setting and gives a higher yield than harvesting at full maturity. Green fruits are sufficiently mature for harvest when firm; sweet peppers, if gently squeezed, make a characteristic popping sound. Harvesting is done by hand, except for big fruits and sweet peppers that are harvested with a small knife. The picking of small-fruited types like bird peppers is very labour intensive. Chillies or sweet pepper destined for trade as dried fruits, powder or oleoresin are left to dry on the plant before harvesting.

Yield Hot pepper yields vary widely from 1.5–18 t/ha fresh product. Sweet pepper may yield up to 30 t/ha in the field and up to 100 t/ha in protected cultivation. The yield level in African countries is generally very low as a consequence of extensive cultivation technology. In Ethiopia the average yield of dried fruits is 400 kg/ha in sole cropping (equalling about 1600 kg/ha fresh product); the maximum yield is 2 t/ha of dried fruits (8 t/ha fresh).

Handling after harvest Capsicum is handled for fresh consumption or processed into canned, pickled, frozen, fermented, dehydrated or extracted products. Usually the fresh fruits are sold in the market. Marketing in big cities is conducted through wholesale to retail markets, but much is also sold in small street markets through more informal marketing channels. If the price is low, harvested fruits may be sun-dried. This takes place in a vacant field or along roadsides, on mats or a well-swept area. The fruits are put in layers 2–3 fruits thick in the sun and are turned frequently; they will dry adequately in 10–20 days. The weight loss during drying is 60–80%. Dried fruits are used for preparation of powder or in ketchups and mixed spices. Handling of dry hot peppers for processing or seed extraction is very unpleasant because of the dust containing capsaicin,

and precautions for protection of the skin and eyes are needed. Fresh fruits can be stored for up to 5 weeks at 4°C and 95% humidity. Dried capsicum may be stored for many months to supply year-round demands.

Genetic resources An extensive germplasm collection of over 3000 accessions is held in the United States Plant Germplasm System, and another global collection is present at the Asian Vegetable Research and Development Center (AVRDC) in Taiwan. Other collections are held at the Centro Agronómico Tropical de Investigatión y Enseñanza (CATIE), Turrialba, Costa Rica, at the Centre for Genetic Resources (CGN), Wageningen, Netherlands, and at the Central Institute for Genetics and Germplasm, Gatersleben, Germany. There are many working collections of *Capsicum* germplasm. In Africa collections are held at Bako Research Centre in Ethiopia, and at the Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria. Other collections of landraces and traditional cultivars are present in several African countries, e.g. Kenya, Sudan and Zambia.

The genetic diversity available within *Capsicum* has been little exploited. The fairly high degree of cross-pollination is responsible for much of the heterogeneity in collected accessions. The wild species are potentially important as genitors of valuable disease resistance genes. In Africa most farmers still save and use their own seed. In the future, many landraces and local cultivars are likely to disappear as African growers will switch to improved cultivars, and hence there is a need for collecting the traditional capsicum material and conserving it in genebanks.

Breeding Much breeding work has been performed on sweet pepper in temperate regions. Many cultivars, at present mostly F_1 hybrids, are commercially available for glasshouse and field production. Capsicum shows rather strong heterosis effects for plant growth traits and yield. The use of molecular markers and doubled haploids is quite common. Capsicum is very appropriate for the development of F_1 hybrids, with cultivars superior in yield, uniformity and disease resistance. Hybrid seed is produced by hand emasculation and pollination of the right inbred lines, a very labour-intensive method. The use of cytoplasmic male sterility is advancing but still rather unreliable. Sweet pepper cultivars bred especially for tropical African conditions are scarce. Seed company Technisem supplies seed of cultivar 'Capela' resistant to high temperature, TMV and PVY, F_1 cultivar 'Stella' resistant to TMV, and 'Arika' resistant to TMV and PVY. The South African seed company Hygrotech has paprika cultivars grown in Zimbabwe for oleoresin production, e.g. the popular cultivar 'Papri Queen', which is an erect subshrub, resistant to powdery mildew, taking 95–105 days to fruit maturity, with elongated, thin-walled, red fruits c. 17 cm × 3 cm.

Breeding for hot pepper is far less developed than for sweet pepper. Resistance breeding for fungal, bacterial and virus diseases is promising. At Plant Research International, Wageningen University and Research Centre, Netherlands, resistance genes for anthracnose were found in chillies, bird pepper and aromatic pepper, as well as in *Capsicum baccatum*. Many African accessions with resistance genes against the important viruses have been reported. Some commercial cultivars, including superior F_1 hybrids for the tropics, are available from Korea, Japan, India, Taiwan, Thailand and Indonesia. Resistance breeding with local hot pepper cultivars in Indonesia (East-West Seed Company) resulted in hybrid cultivars with a certain degree of resistance to anthracnose, bacterial wilt and fruit fly. Breeding work has been reported from Nigeria (Zaria, Ilorin, Ibadan) and Ethiopia. In Africa F_1 hybrids are still rarely used because the seed is expensive and few F_1 cultivars bred for local African conditions are available. Technisem seed company selected cultivars for tropical Africa, such as the aromatic hot pepper cultivars 'Safi', 'Antillais Caribbean', 'Jaune du Burkina' and 'Big Sun', the chilli cultivars 'Jalapeno' and F_1 'Sunny', and the bird peppers 'Salmon', 'Soudanais', 'Thailande' and 'Pili Pili'. Breeding for disease resistance takes precedence in most programmes, although yield, abiotic stress tolerance (heavy rainfall, fruit setting during hot weather), earliness and market quality concerning fruit shape, pungency, flavour and colour are overall objectives for capsicum improvement in the tropics. An intertropical network for plant breeding known as LIRA was initiated since 1992 as a collaboration between the Institut National de la Recherche Agronomique (INRA) in France and the Ministry of Agriculture in Cuba. The objective is the breeding for durable resistance against worldwide potyviruses. Since 1994 Guadeloupe, Tanzania, Sudan and Senegal have joined this programme. In several African countries, national programmes and private

seed companies play a role in supplying seed of improved cultivars. Heterogeneous local cultivars are better suited for homegardens and small scale farming because of the prolonged harvest period, but less for large-scale market production. A good seed yield of open pollinated cultivars is 500 kg/ha, for hybrid hot pepper 200 kg and hybrid sweet pepper 150 kg.
Research institutes and seed companies in Western countries are using more and more advanced biotechnology, such as isozymes for selection. At present they use molecular biotechnology, mainly Restriction Fragment Length Polymorphisms (RFLP), Randomly Amplified Polymorphic DNA (RAPD) and Amplified Fragment Length Polymorphism (AFLP) markers and double haploids derived from anther culture, for mapping the genome. Molecular markers are used for efficient screening on disease resistances and speeding up the breeding period. Crossings can be made with all cultivated and most wild *Capsicum* species using embryo rescue.

Prospects Capsicum peppers have a high nutritional and economic value, but the average yield in Africa is still very low. With improved cultivars, especially hybrid cultivars, and higher input use and intensification of cultural practices, the yield level can be increased considerably. Sweet pepper cultivation should be extended to supply urban markets and in some countries for export. In West Africa the mild forms of the aromatic hot pepper merit attention. There is a need for heat-tolerant sweet pepper cultivars suitable for lowland cultivation.
Breeding of hot pepper (chillies and aromatic hot pepper) and seed production based on local cultivars, with emphasis on resistance to pests and diseases, merits high priority. Practical knowledge on integrated pest management for capsicum in the tropics is lacking and requires much research as well as training of farmers.

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Sources of illustration Poulos, J.M., 1993.

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CARALLUMA EDULIS (Edgew.) Benth. ex Hook.f.

Protologue Fl. Brit. India 4: 76 (1883).

Family Asclepiadaceae (APG: Apocynaceae)

Chromosome number $2n = 22, 44$

Synonyms *Caralluma longidens* N.E.Br. (1892), *Caralluma vittata* N.E.Br. (1903), *Caralluma mouretii* A.Chev. (1934), *Cryptolluma edulis* (Edgew.) Plowes (1995).

Vernacular names Edible caralluma (En). Caralluma comestible (Fr).

Origin and geographic distribution *Caralluma edulis* has been reported from Mauritania, Sudan, Eritrea, Somalia, Saudi Arabia, United Arab Emirates, Pakistan, India and possibly Iran and Afghanistan.

Uses *Caralluma edulis* is used raw as a vegetable in Mauritania. In India fresh stems are sold as a vegetable in local shops ('situn'). As a succulent herb it has ornamental value.

Properties The stems are slightly acid. In a test in Pakistan to verify a possible hypoglycaemic effect of powdered *Caralluma edulis* roots, doses of 2–4 g/kg body-weight did not show any effect in normal or diabetic rabbits. There is no information on the phytochemistry of *Caralluma edulis*. Highly toxic glycosides have been found in several other *Caralluma* species (e.g. in *Caralluma acutangula* (Decne.) N.E.Br., *Caralluma gracilipes* K.Schum. and *Caralluma penicillata* (Defl.) N.E.Br.).

Botany Slightly succulent herb with slender, much branched, subterete stem 20–30 cm tall, at apex tapering to a pointed tip. Leaves opposite, simple, small, caducous, sometimes prominent, semi-persistent and up to 1 cm long. Flowers 1–2 together, extra-axillary near the stem apex, bisexual, 5-merous, about 8 mm in diameter, on slender curved pedicels 4–6 mm long; calyx-lobes ovate-lanceolate, 3–4 mm long, glabrous; corolla tube campanulate-urceolate, 7–8 mm long and broad, subglabrous, yellow-green, longitudinally ridged inside, corolla limb dark purple with a narrow disk and erect, oblong-triangular lobes 5 mm × 2.5 mm; outer corona lobes bipartite, forming

10 filiform horns 5 mm long, inner corona lobes longer than the outer ones, strap-shaped, incumbent on the anthers; anthers short, truncated, without appendages.
The taxonomy of the genus and species is still in dispute. According to Plowes the correct name for this species is *Cryptolluma edulis* (Edgew.) Plowes and the first 3 synonyms mentioned here are considered to represent different, separate species.

Ecology *Caralluma edulis* occurs usually in dry sandy locations, from sea-level up to 1300 m altitude. In its distribution area it flowers and fruits year-round.

Management *Caralluma edulis* is occasionally cultivated as a vegetable and as an ornamental.

Genetic resources and breeding *Caralluma edulis* is nowhere a common plant and it should be protected wherever it occurs naturally.

Prospects Because *Caralluma edulis* is able to grow in dry, sandy locations it deserves more research attention concerning its phytochemistry, nutritive properties and cultivation possibilities.

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Authors P.C.M. Jansen

CARDAMINE TRICHOCARPA Hochst. ex A.Rich.

Protologue Tent. fl. abyss. 1: 18 (1847).
Family Brassicaceae (Cruciferae)
Chromosome number $2n = 32$
Vernacular names Hairy bittercress (En). Cressonnette (Fr). Kisegeju (Sw).

Origin and geographic distribution *Cardamine trichocarpa* is found in mountainous areas of central and eastern Africa, from Cameroon and Angola to Ethiopia and Tanzania. It is also found in Madagascar and India.

Uses In Uganda, eastern DR Congo and Tanzania, the leaves of *Cardamine trichocarpa* are collected from the wild, wilted, chopped, boiled and eaten as a vegetable, alone with a staple food or in a mixture with beans or peas. They are also used as fodder for goats and rabbits. In Uganda this vegetable is considered useful to treat kwashiorkor. The crushed leaves are used as a dressing on wounds for 2–3 days to improve healing, and they also make a good herbal bath for babies.

Botany Erect or ascending, annual herb up to 50 cm tall; stem unbranched or profusely branched from the base. Leaves alternate, in outline oblong, up to 15 cm long, imparipinnate with 3–11 leaflets, bearing rather stiff hairs; leaflets ovate, up to 5 cm long with stalks up to 1 cm long, lowest pairs smallest, apex acute, margin serrate to crenate. Inflorescence usually a terminal, densely flowered, stalked raceme up to 20 cm long in fruit. Flowers bisexual, regular, 4-merous, small, greenish, often cleistogamous; pedicel in fruit up to 7 mm long; sepals oblong, up to 2 mm long, with scattered hairs; petals white, shorter than sepals or absent; stamens 4; ovary superior, 2-celled, cylindrical, stigma sessile. Fruit a linear silique up to 2.5 cm × 1.5 mm, with scattered hairs. Seeds broadly oblong in outline, c. 1.5 mm × 1 mm, red-brown, minutely rugose.
Cardamine comprises about 130 species in subarctic, temperate and montane tropical areas all over the world, most abundantly in the Northern Hemisphere, especially in moist localities. In Africa 4 species occur. The leaves of *Cardamine hirsuta* L. (smaller than *Cardamine trichocarpa* with petals longer than sepals and glabrous fruits, originating from Europe but occurring in Africa in the same areas as *Cardamine trichocarpa*) are used as a vegetable in Europe and possibly also in Africa. In Cameroon they are boiled in soup and said to have stomachic properties.

Ecology *Cardamine trichocarpa* occurs in open, somewhat moist localities and along roadsides, in mountainous areas at 700–3100 m altitude. It is increasingly spreading as a weed, also at lower altitudes, and is particularly noxious in rice fields. In Uganda and Tanzania average annual rainfall in areas where it grows is 1200–1800 mm.

Genetic resources and breeding *Cardamine trichocarpa* is widespread and not in danger of genetic erosion.

Prospects Although several wild *Cardamine* species are locally popular leafy vegetables in Europe, it is expected that in Africa *Cardamine trichocarpa* will remain a minor vegetable only of some local importance in mountainous areas.

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CAYLUSEA ABYSSINICA (Fresen.) Fisch. & C.A.Mey.

Protologue Index sem. hort. petrop. 7: 41 (1841).
Family Resedaceae
Synonyms *Reseda abyssinica* Fresen. (1837).
Origin and geographic distribution *Caylusea abyssinica* is distributed in eastern Africa, where it is found in Sudan, Ethiopia, Kenya, Uganda, Rwanda, Burundi, Tanzania and Malawi.
Uses In Tanzania tender leaves and stems of *Caylusea abyssinica* are collected from the wild, washed, chopped, cooked and eaten mixed with other vegetables. Often pounded pumpkin, sunflower or hemp seed or groundnut paste are added and the mixture is eaten alone or with a staple food. In Ethiopia the leaves are also used as a cooked vegetable. Boiled leaves are also used to treat stomach-ache and to expel intestinal worms. Ash of the whole burnt plant or a root decoction is taken as a remedy for abdominal pain in East Africa. *Caylusea abyssinica* is also used as fodder for goats and rabbits, and occasionally it is planted as an ornamental.
Properties In Ethiopia seeds of *Caylusea abyssinica*, which get among the tef (*Eragrostis tef* (Zucc.) Trotter) harvest, are said to make the tef pancake ('injera') bitter. Seed is said to be poisonous to livestock.
Botany Erect herb up to 1.5 m tall, with slightly woody taproot and glabrous stem. Leaves alternate, sometimes upper leaves whorled, simple, sessile, axils often with clusters of smaller leaves or short branches; blade linear to lanceolate-elliptical, 2–9 cm × 0.5–2.5 cm, margin sometimes undulate, often rough or toothed. Inflorescence a dense spike-like raceme up to 40 cm long, rachis acutely ribbed, bracteate. Flowers bisexual, 5-merous, small; pedicel 1–2 mm long; sepals linear, 1.5–2.5 mm long; petals unequal, clawed, 3–4 mm long, white, 2 upper ones divided into 4–5 lobes, other ones entire or 2–3-lobed; stamens 10–13, filaments 3 mm long, anthers brightly reddish; ovary consisting of 5–7 free, boat-shaped carpels fused at base and rough at edges, each carpel bearing a short tooth-like style and stigma. Fruit consisting of stellately spreading mericarps splitting longitudinally. Seeds reniform, c. 1.5 mm × 1 mm, brown-black, wrinkled in a fine tiled pattern.
Caylusea comprises 4 species and is distributed in the Mediterranean region, and northern and eastern Africa.
Ecology *Caylusea abyssinica* is a non-aggressive weed and is found in open grassland, fields, roadsides and rocky areas, at 1500–2750 m altitude.
Management *Caylusea abyssinica* is usually collected from the wild, but people sometimes retain the plants when they grow in the garden or around the house.
Genetic resources and breeding *Caylusea abyssinica* is widespread and not in danger of genetic erosion.
Prospects *Caylusea abyssinica* will remain a minor vegetable. Its nutritional composition and medicinal properties need investigation.
Major references Abdallah, M.S., 1967; Kokwaro, J.O., 1993; Ruffo, C.K., Birnie, A. & Tengnäs, B., 2002; Westphal, E., 1975.
Other references de Wit, H.C.D., 2000; Elffers, J. & Taylor, P., 1958; Robyns, W., 1951.
Authors P.C.M. Jansen

CAYRATIA DEBILIS (Baker) Suess.

Protologue Mitt. Bot. Staatssamml. München 1(8): 352 (1953).
Family Vitaceae
Synonyms *Cissus debilis* (Baker) Planch. (1887).
Vernacular names Liane à saucisses (Fr).
Origin and geographic distribution *Cayratia debilis* is native to equatorial Africa from Liberia to southern Sudan and western Uganda.
Uses The leaves of *Cayratia debilis* are eaten as a vegetable in Bioko (Fernando Po). In Congo the leaves are eaten by people suffering from heart trouble and a herb tea is drunk to relieve cough. In Gabon the sap is used as an ointment to heal the umbilical cord. In Côte d'Ivoire a leaf decoction is taken internally and applied externally as an embrocation in the treatment of headaches. Grated stems are made into poultices to apply to abscesses to draw out pus. In Congo the stems are part of a mixture to remedy abdominal troubles and constipation. The stems are used in a mixture with *Tephrosia* leaves as a fish poison.

The fruits are inedible but have veterinary use in the Central African Republic. They are crushed in water and the solution is given to poultry as a prophylactic for coccidiosis and avian influenza.

Properties No chemical data are known for *Cayratia debilis*, but leaves of *Cayratia trifolia* (L.) Domin, as well as those of some other Asiatic species, were found to contain several flavonoids including cyanidin, delphinidin, kaempferol, myricetin and quercetin. The aerial parts of *Cayratia trifolia* contain the triterpene epifriedelanol, a compound with demonstrated antitumour activity, whereas the stem, leaves and roots contain cyanic acid.

Botany Herbaceous or slightly woody, branched, perennial climber with leaf-opposed, branched tendrils; stems slender, up to 5 m long. Leaves alternate, pedately 5-foliolate; stipules oblong, up to 3 mm long; petiole 4–12 cm long; leaflets elliptical to oblong-obovate, base cuneate to rounded, apex acuminate, up to 12 cm × 5.5 cm. Inflorescence an irregular, lax, corymbose cyme 10–25 cm long. Flowers unisexual or bisexual, 4-merous; calyx cup-shaped, entire or shallowly lobed; petals triangular, greenish white or yellow, 1.5 mm long; stamens c. 0.5 mm long; ovary glabrous, immersed in disk. Fruit a fleshy, slightly flattened berry, 3 mm × 5 mm, white turning lilac, blue-black or mauve, 2–4-seeded.

Cayratia comprises about 50 species and is distributed in the tropics of the Old World. The closely related *Cayratia gracilis* (Guill. & Perr.) Suess. can be distinguished from the otherwise similar *Cayratia debilis*, with a partial overlapping distribution, by the smaller inflorescences, smaller seeds and ovate, rather than oblong, leaflets. The genus has quite a few species with medicinal uses.

Ecology *Cayratia debilis* is a species of primary, secondary and gallery forests.

Management *Cayratia debilis* is harvested from the wild whenever the need arises.

Genetic resources and breeding In view of the wide distribution, genetic erosion does not seem a risk at present. There are no accessions known in accessible germplasm collections.

Prospects There is no information on the phytochemistry and pharmacological properties of *Cayratia debilis*. In view of its use as a vegetable and many medicinal uses, as well as results from related Asiatic species, research is desirable.

Major references Burkill, H.M., 2000; Descoings, B., 1972; Slamet Sutanti Budi Rahayu, 2001; Raponda-Walker, A. & Sillans, R., 1961.

Other references Projet CAD, 2000.

Authors C.H. Bosch

CAYRATIA GRACILIS (Guill. & Perr.) Suess.

Protologue Mitt. Bot. Staatssamml. München 1(8): 352 (1953).

Family Vitaceae

Synonyms *Cissus gracilis* Guill. & Perr. (1831).

Origin and geographic distribution *Cayratia gracilis* is widespread in tropical Africa from Senegal to Sudan and Eritrea and south to Mozambique, Zimbabwe, Botswana and Namibia; also in South Africa and Yemen.

Uses The leaves of *Cayratia gracilis* are occasionally eaten as a vegetable in Sudan. Elsewhere use as a vegetable is limited. In Senegal it is considered a famine food that needs to be cooked together with *Amorphophallus* roots.

In Tanzania the pulped leaves are rubbed topically on slight incisions to treat lumbago. Crushed leaves mixed with *Momordica foetida* Schum. stop the irritation caused by the spittle of the spitting cobra when rubbed on the affected area. Fresh roots are chewed or boiled and the decoction used as a cough remedy.

Properties The crushed leaves have a strong smell but no chemical data are known for *Cayratia gracilis*. The leaves of *Cayratia trifolia* (L.) Domin, as well as those of several other Asiatic species of the genus, were found to contain several flavonoids including cyanidin, delphinidin, kaempferol, myricetin and quercetin. The aerial parts of *Cayratia trifolia* contain the triterpene epifriedelanol, a compound with demonstrated antitumour activity, whereas the stem, leaves and roots contain cyanic acid.

Botany Climbing or trailing perennial herb, with leaf-opposed, branched tendrils; stems slender, up to 7.5 m long. Leaves alternate, pedately (3–)5(–9)-foliolate; stipules oblong-triangular, up to 3 mm long, early caducous; petiole 4–6 cm long; leaflets ovate or elliptical, up to 10 cm × 6 cm, base broadly cuneate to cordate, apex acuminate. Inflorescence an irregular, lax, corymbose cyme 5–10 cm long. Flowers unisexual or bisexual, 4-merous; calyx cup-shaped, entire; petals whitish, yellow or pale green; stamens c. 1 mm long; ovary glabrous. Fruit a fleshy, globose or depressed-globose berry 6.5–10 mm in diameter, black,

2(–4)-seeded. Seeds strongly ridged, c. 5 mm × 4 mm.

Cayratia comprises about 50 species and is distributed in the tropics of the Old World. The closely related *Cayratia debilis* (Baker) Suess., a species with a partial overlapping distribution, can be distinguished from the otherwise very similar *Cayratia gracilis* by the larger inflorescences, larger seeds and oblong, rather than ovate, leaflets. The genus has quite a few species with medicinal uses.

Ecology *Cayratia gracilis* is found in various types of forests and woodlands from sea-level up to 1800 m altitude.

Genetic resources and breeding In view of the wide distribution, genetic erosion does not seem a risk at present. There are no accessions known in accessible germplasm collections.

Prospects There is no information on the phytochemistry or pharmacological properties of *Cayratia gracilis*. In view of its use as a vegetable and many medicinal uses, as well as results from related Asiatic species, research is desirable.

Major references Burkill, H.M., 2000; Kokwaro, J.O., 1993; Verdcourt, B., 1993; Slamet Sutanti Budi Rahayu, 2001.

Other references Descoings, B., 1972.

Authors C.H. Bosch

CELOSIA ARGENTEA L.

Protologue Sp. pl. 1: 205 (1753).

Family Amaranthaceae

Chromosome number $2n = 36, 72, 108$

Vernacular names Celosia, Lagos spinach, soko, quail grass, cock's comb (En). Célosie, célosie argentée, crête de coq (Fr). Amaranto branco (Po). Mfungu (Sw).

Origin and geographic distribution The wide diversity of *Celosia argentea* in tropical Africa points to an origin in this region. *Celosia argentea* is a widespread weed throughout tropical Africa, from Senegal east to Somalia and south to northern South Africa and the Indian Ocean islands, and a traditional vegetable in West and Central Africa. It is one of the leading leaf vegetables in south-western Nigeria, where it is known as 'soko yòkòtò' in the Yoruba language, meaning 'make husbands fat and happy'. It is extremely important as well in southern Benin, also popular in Togo, Ghana and Cameroon, and recorded as a vegetable from several other West and Central African countries. Outside Africa, it occurs in tropical and subtropical Asia and America. The ornamental forms of *Celosia argentea* with fasciated inflorescences (cock's comb) probably originate from India. These are widely grown as an ornamental in the tropics and subtropics, and in summer in temperate regions.

Celosia argentea – wild and planted

Uses Celosia is primarily used as a leafy vegetable. The leaves and tender stems are cooked into soups, sauces or stews with various ingredients including other vegetables such as onions, hot pepper and tomato, and with meat or fish and palm oil. Celosia leaves are tender and break down easily when cooked only briefly. The soup is consumed with the staple food of maize, rice, cassava or yam. The young inflorescences are also eaten as a potherb.

In Kenya, the Masai use the liquid extract from the leaves and flowers as a bodywash for convalescents. The whole plant is used as an antidote for snakebites and the roots to treat colic, gonorrhoea and eczema. In Ethiopia and DR Congo the seeds are used as medicine for diarrhoea, and in Ethiopia the flowers to treat dysentery and muscle troubles. In China, the leaves are used as medicine in the treatment of infected sores, wounds and skin eruptions, and in China and Japan seed extracts have traditionally been used as a therapeutic drug for eye and hepatic diseases. In India, the leaves mixed with honey are applied to inflated areas or abscesses, and the seeds are widely used for the treatment of diabetes mellitus. In South-East Asia, the flowers are used as medicine for dysentery, haemoptysis and menstruation problems. In DR Congo the plant is associated with occult and witchcraft beliefs. Celosia can

also be used as a livestock feed. Forms with fasciated, yellow to red inflorescences are widely grown as a bedding plant in gardens and also used as cut flowers. These are also planted in Africa.

Production and international trade Celosia is cultivated on small and scattered plots in home gardens, farmland and urban and peri-urban areas making it difficult to estimate the cultivated area, but it must amount to thousands of hectares. It is a vegetable of high economic value, particularly in the dry season, and commands market prices similar to those of amaranth (*Amaranthus cruentus* L.). In Benin and Nigeria, young celosia plants are sold in small bundles (0.5–1.0 kg) in main and small street markets. There is no registered international trade, but occasionally small quantities are exported from Nigeria to the United Kingdom and the United States for sales to the resident African communities.

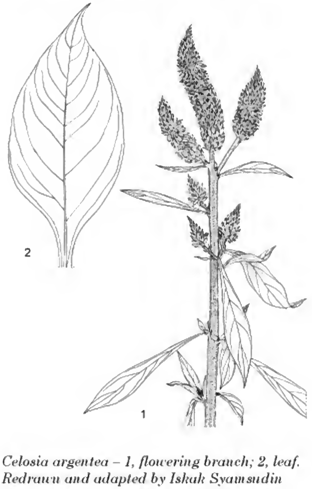
Properties The composition of *Celosia argentea* per 100 g edible portion is: water 83.8 g, energy 185 kJ (44 kcal), protein 4.7 g, fat 0.7 g, carbohydrate 7.3 g, fibre 1.8 g, Ca 260 mg, P 43 mg, Fe 7.8 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). It is a dark green leafy vegetable with a high content of micronutrients, comparable with amaranth (*Amaranthus cruentus*). Young leaves harvested 5–7 weeks after sowing have the best nutritional value and are especially rich in Fe, vitamin A and vitamin C. The leaves contain phytic acid (120 mg/100g) and oxalic acid (20 mg/100g). The high oxalic acid content makes the leaves less suitable for fresh consumption. The composition is strongly influenced by environmental factors, e.g. soil fertility, fertilizer application and age of plant at harvest.

In tests in India, *Celosia argentea* seeds reduced blood glucose in alloxan-induced diabetic rats. Aqueous seed extracts showed antimetastatic and immunomodulating properties in tests with mice. The acidic polysaccharide celosian isolated from the seeds was found to be a potent antihepatotoxic agent for chemical and immunological liver injury models in animals. The antimitotic bicyclic peptides celogentins A–C and moroidin have been isolated from the seeds, and an antiviral protein has been isolated from the leaves.

Celosia argentea contains red betacyanins and yellow betaxanthins which are being tested as food colorants. Several glycopyranosyls have been isolated from celosia, including citrusin C which has skin depigmentation properties. The seed of *Celosia argentea* contains a fatty oil known as 'celosia oil' in India.

Adulterations and substitutes In dishes, leafy vegetables prepared in the same way, especially amaranths and other *Celosia* species, can be used as a substitute for *Celosia argentea*.

Description Erect annual herb up to 2 m tall; stem ridged, glabrous, branches up to 25 per plant, ascending. Leaves alternate, simple, without stipules; petiole indistinctly demarcated; blade ovate to lanceolate-oblong or narrowly linear, up to 15(–20) cm × 7(–9) cm, tapering at base, acute to obtuse and shortly mucronate at apex, entire, glabrous, pinnately veined. Inflorescence a dense, many-flowered spike, at first conical but becoming cylindrical, up to 20 cm long, bracteate, silvery to pink, in ornamental forms completely or partly sterile and in many colours. Flowers small, bisexual, regular, 5-merous; tepals free, narrowly elliptical-oblong, 6–10 mm long; stamens fused at base; ovary superior, 1-celled, style filiform, up to 7 mm long, stigmas 2–3, very short. Fruit an ovoid to globose capsule 3–4 mm long, circumscissile, few-seeded. Seeds lenticular, 1–1.5 mm long, black and shining, shallowly reticulate.



Celosia argentea – 1, flowering branch; 2, leaf. Redrawn and adapted by Iskak Syamsudin

Other botanical information *Celosia* comprises about 50 species and occurs in all tropical and subtropical regions. *Celosia argentea* is by far the most popular and most widely cultivated species. There are three major types of *Celosia argentea* cultivated as vegetable in Nigeria and Benin: green broad-leaved cultivars called 'Soko green'; broad-leaved cultivars with anthocyanin pigmentation of the leaf blades and parts of the stem called 'Soko pupa'; and cultivars with deep green narrow leaves with a hard texture and early flowering. ' Soko pupa' imparts the anthocyanin-red colour into the soup, making it less popular than 'Soko green'. Improved cultivars of 'Soko green' with broad pale green leaves are more vigorous.

Ornamental types of *Celosia argentea* with fasciated inflorescences have been described as *Celosia cristata* L. and were later considered as a variety or form of *Celosia argentea*. They are tetraploid ($2n$ = 36), rarely $12x$ ($2n$ = 108), whereas wild plants are usually octoploid ($2n$ = 72) and rarely tetraploid (in India).

Growth and development The seedling emerges 5–7 days after sowing. Early vegetative growth is slow but flowering may occur already 6–7 weeks after sowing. Improved cultivars have a more rapid early vegetative development but flower later, 12–14 weeks after sowing. The early flowering of local cultivars or wild types makes them less attractive to consumers and more amenable to once-over harvesting by uprooting, whereas the improved cultivars can be harvested by uprooting as well as by repeated cutting. Flowering is delayed by repeated cutting of the tender vegetative parts. Pollination is by wind and insects, especially bees and flies, which visit the flowers regularly. Seed maturity starts from the basal part of the inflorescence and gradually moves up to the tip. Consequently, seeds from the basal parts of the inflorescence are more vigorous than those from the middle and apical regions. Seeds are mature in 10–20 weeks from sowing and shatter when the inflorescence is dry. They remain dormant on the soil surface until the start of the next rainy season.

Ecology Celosia grows well in the lowland humid forest zone at day temperatures of 30–35°C and night temperatures of 23–28°C and at an altitude up to 1700 m. Growth is greatly retarded by temperatures below 20°C, consequently it does not grow well in the savanna region of West Africa during the harmattan period. Celosia performs well under partial shade, especially in dry conditions. Photosynthesis in celosia follows the C_3-cycle pathway; therefore about 60% of full sunlight is adequate for optimal growth, making celosia especially suitable for production in shady home gardens. A well-drained sandy loam soil allows optimum growth, but celosia also grows well on marshy soils. In Nigeria and Benin it is frequently produced during the dry season in so-called 'fadama' cropping systems, i.e. on hydromorphic soils of river banks and seasonally flooded areas. An additional advantage is that the flooding eliminates the *Meloidogyne* root-knot nematode problem. Celosia tolerates moderately saline soils of 25–50 mM NaCl. It is moderately resistant to drought and performs well under low water supply of the dry season, but severe drought promotes early flowering. The rainfall requirement during the rainy season is 500–1000 mm.

Propagation and planting Celosia is grown on raised beds, ridges or flat beds. It is propagated by seed, either direct sown or transplanted. The 1000-seed weight is 1.0–1.1 g. For direct sowing, used for harvesting by uprooting whole young plants, a seed rate of 6–9 g per 10 m² is used for sowing in rows or broadcasting. Seed is sometimes mixed with dry fine sand to obtain an even seed distribution. Direct sowing is prone to excessive use of seed, excessively high plant densities, difficult management, poor vegetative growth and low yield. With transplanting, less seed is required. Seed is then first sown in nursery beds and after 2–3 weeks the seedlings are transplanted. For harvesting by pruning the seedlings are widely spaced (15 cm × 15 cm on the beds), for once-over harvest by uprooting a spacing of 10 cm × 10 cm is adequate. Compared to direct sowing, transplanting gives more uniform and vigorous plants. Crop management, e.g. weeding and fertilizer application, is also easier using transplanting; the yield is high and the plant quality is better. Celosia is often grown in intercropping systems with other vegetables, cassava or yam. For seed production, a number of plants are set aside after the first harvest. These plants are cut at a lower height to encourage the production of lateral shoots. The seed yield is 200–700 kg/ha.

Management No weeding is required if the land is well prepared before sowing and harvesting is by uprooting. In case of wider planting for repeated harvesting with improved cultivars, 1–2 weedings are needed before the start of flowering. In mixed cropping celosia competes better with weeds than Jew's mallow

(*Corchorus olitorius* L.), but less so than amaranth. Irrigation is optional during the rainy season. During the dry season, depending on the severity of heat and evapotranspiration, 2 irrigations per week are recommended, applying a total of 45 mm water. Celosia tolerates dry soil better than amaranth. It responds well to nutrients; a basal fertilizer treatment is not necessary if it is grown on rich soils. For optimum vegetative growth on poor or moderately fertile soils, application of complete NPK fertilizer at a rate of 400 kg/ha in a single dose is needed if the crop is harvested by uprooting, and 600 kg/ha split into two equal applications if the crop is harvested by successive cuttings. Organic manure, e.g. poultry manure, cow dung or domestic refuse, at a rate of 25–40 t/ha is a suitable alternative for inorganic fertilizers. Organic manure will not only increase growth but also reduce the population and effects of root-knot nematodes.

Diseases and pests Celosia is susceptible to several leaf fungi, which can be severe when air humidity is high and during rainy weather and result in poor leaf quality. *Cercospora celosiae* causes red-rimmed grey spots on the leaves. White rust (*Albugo bliti*) forms white pustules on the underside of the leaves. Other diseases affecting the leaf quality are Alternaria leaf spot (*Alternaria* spp.) and charcoal rot (*Macrophomina phaseolina*, *Curvularia* spp.), which cause dark spots on the leaves. Wet rot or stem rot caused by *Choanephora cucurbitarum*, the main disease of amaranth during the wet season, is sometimes serious in densely planted celosia. *Rhizoctonia solani* and *Pythium aphanidermatum* cause damping-off of seedlings. Celosia is highly susceptible to root-knot nematodes (*Meloidogyne* spp.) causing galls on roots, unthrifty growth, small and chocolate-coloured leaves as well as reductions in yield of up to 40%. It is therefore recommended that celosia not be grown continuously and that it not be followed by other crops susceptible to root-knot nematodes such as okra, gboma eggplant, Jew's mallow, lettuce or tomato. Variation in degree of susceptibility to root-knot nematodes exists among cultivars, but no resistant cultivars have been reported. However, the application of much organic manure reduces the nematode population, as well as annual flooding. Caterpillars of *Hymenia recurvalis* and *Psara bipunctalis* feed on the leaves. The use of appropriate pesticides can control them. Spraying should start at detection of the caterpillars and should be applied once a week for three weeks. Grasshoppers and aphids cause minor damage in celosia.

Harvesting Celosia is harvested either by uprooting or by repeated pruning of the stem which encourages production of side shoots for further cuttings. Growers at times combine the two methods, first uprooting as a thinning operation to encourage vigorous growth among the remaining plants, which are then harvested by repeated cutting. Depending on soil fertility and moisture, the crop is ready for uprooting 4–5 weeks after direct seeding or about 4 weeks after transplanting. The first cutting is carried out at a height of 10–15 cm leaving a sufficient number of axillary buds for the production of lateral shoots. Subsequent cuttings are carried out at 2-weekly intervals, allowing 4–5 harvests before the start of flowering. Flowering is delayed by regular cutting. Traditional cultivars flower earlier than improved ones and are therefore not suitable for harvesting by repeated cutting.

Yield In an experiment in Nigeria a yield of a well-managed crop harvested by uprooting was 47 t/ha, while repeated cuttings yielded 57 t/ha. Repeated cuttings also resulted in a better quality of the produce and less inedible waste and gave a higher economic return. Although celosia is a productive leafy vegetable, its yields are lower than those of amaranth.

Handling after harvest Harvested plants are bundled and tied after washing of soil from the roots. They are then sprinkled with water to keep them fresh for marketing. If harvested late in the evening, the plants are spread on a roof overnight and kept fresh by the night dew. In the market, the plants are tied into small-sized bundles of 0.5–1.0 kg for sale. They are kept covered by jute cloth and regularly watered. Shelf life of uprooted plants is extended by 2–3 days by keeping the roots in a basin with water.

Genetic resources A collection of *Celosia* germplasm is maintained at NIHORT, Ibadan, Nigeria and several working collections are maintained elsewhere in West Africa. *Celosia argentea* is one of the 24 vegetable species identified by IBPGR in 1979 which show genetic erosion and are of local importance or rank second in priority on global scale. Germplasm collections are required for conservation, screening and selection of improved cultivars.

Breeding Limited breeding work has been done on celosia. In Nigeria selections have been made in local and improved cultivars based on leaf size and shape, and on flowering period.

Lines have been selected for low red or purple colouration in the leaves. Completely green cultivars were selected in Benin and Nigeria and are now generally used. Improved cultivars are more efficient in terms of leaf production and leaf area per plant than the unselected local cultivars.

Prospects *Celosia argentea* is a nutritious and easy to cultivate vegetable, important for southern Nigeria and Benin and with potential for other lowland areas. Improved Nigerian cultivars are late maturing and suitable for repeated cuttings, and have a high yield under proper management. Suitable cultivars with rapid early vegetative growth should be selected for harvesting by uprooting. Breeding and selection work should aim at the development of cultivars with resistance to diseases and pests, particularly root-knot nematodes. Research should also focus on the development of adequate cultural practices in sole and intercropping systems, including irrigation. Simple and cheap storage systems that can be used to prolong the shelf life of harvested seedlings as well as ensure good leaf quality for marketing are also required.

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Sources of illustration Grubben, G.J.H., 1975.

Authors O.A. Denton

CELOSIA TRIGYNA L.

Protologue Mant. pl. 2: 212 (1771).
Family Amaranthaceae
Chromosome number $2n = 18$
Synonyms *Celosia laxa* Schumach. & Thonn. (1827), *Celosia digyna* Suess. (1951).

Vernacular names Silver spinach, woolflower, cock's comb (En). Célosie, crête de coq (Fr). Bórôbóró déo (Po). Mfungu (Sw).

Origin and geographic distribution *Celosia trigyna* occurs almost throughout tropical Africa, also in South Africa and southern Arabia, often as a weed. It is recorded as a leafy vegetable in Benin and southern Nigeria, but also in South Africa. *Celosia trigyna* has been introduced in the United States, where it is locally naturalized.

Uses *Celosia trigyna* leaves are consumed as a vegetable, finely cut in soups, stews and sauces. The slightly bitter leaves are popular amongst the Yoruba people in south-western Nigeria, where the plant is known as 'aje fo wo'.

The plant is used in traditional medicine. In Sierra Leone it is used for the treatment of heart complaints, whereas in northern Nigeria it is used to treat pustular skin eruption. In Ghana it is applied to sores and boils. Pulped leaves are used to treat costal pains, chest troubles, stomach-ache and urethral disorders. The plant is included in several medicinal preparations used to treat women's disorders and diseases, including ovarian troubles in DR Congo and excessive menstruation in Ethiopia. The leaves and flowers are used to treat diarrhoea. The plant is eaten by livestock, but reports on its acceptability are contradictory.

Celosia trigyna – wild

Production and international trade *Celosia trigyna* is a minor vegetable sold in local and city markets. Production data are not available.

Properties The nutritional composition of *Celosia trigyna* leaves per 100 g edible portion is: water 89 g, energy 138 kJ (33 kcal), protein 2.7 g, fat 0.4 g, carbohydrate 6.4 g, fibre 1.4 g, Ca 154 mg, P 32 mg, Fe 5.0 mg, β-carotene 1.9 mg, riboflavin 0.1 mg, ascorbic acid 10 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968).
Celosia trigyna has shown anthelmintic properties in humans; methanol extracts of the whole plant have shown acaricidal properties.

Adulterations and substitutes Leaves of *Celosia trigyna* used in soups can be replaced by leaves of *Celosia argentea* L. and several *Amaranthus* species.

Description Erect annual herb up to 120(–180) cm tall; stem simple or branched, grooved or striate, glabrous or with few hairs, usually pinkish brown. Leaves alternate, simple, without stipules; petiole up to 5(–8) cm long; blade broadly ovate to narrowly lanceolate, (1–)2–8.5(–10) cm × (0.5–)1– 4(–5) cm, tapering to truncate at base, acute to acuminate at apex, entire, glabrous or slightly shortly hairy below, pinnately veined. Inflorescence an axillary and terminal simple or branched spike 6.5–35 cm long, formed of distant or approximate clusters of flowers, bracteate, silvery to pink. Flowers small, bisexual, regular, 5-merous; tepals free, ovate-elliptical, 2–3 mm long, shortly mucronate; stamens fused at base; ovary superior, 1-celled, style very short, stigmas 2–3. Fruit an ovoid capsule c. 2 mm long, circumscissile, few-seeded. Seeds lenticular, c. 1 mm long, black and shining, shallowly reticulate.

Celosia trigyna – 1, plant habit; 2, flowering branch.
Redrawn and adapted by Iskak Syamsudin

Other botanical information *Celosia* comprises about 50 species and occurs in all tropical and subtropical regions. *Celosia trigyna* is probably the most widespread species in tropical Africa. It differs from many other *Celosia* species in its chromosome number, being diploid, and is considered to have an isolated position within the genus.
Some other species are often confused with *Celosia trigyna* and these are probably used as a vegetable as well: *Celosia globosa* Schinz (found from Nigeria to Uganda), *Celosia isertii* C.C.Towns. (throughout tropical Africa except the north-eastern part), *Celosia leptostachya* Benth. (Sierra Leone to DR Congo) and *Celosia pseudovirgata* Schinz (Nigeria to DR Congo).

Growth and development Seed germinates 4–5 days after sowing. The growing period is 90–120 days from planting to seed maturity. The flowers are pollinated by insects.

Ecology *Celosia trigyna* occurs in forest clearings and grassland, along roadsides and rivers, and as a weed in fields, up to 1500(–2000) m altitude. It requires up to 2500 mm annual rainfall and maximum temperatures of 25–30°C for optimum growth, and does not tolerate temperatures below 15°C. It grows on a wide range of soils, but prefers fertile well-drained loamy soils.

Propagation and planting *Celosia trigyna* is propagated by seed, which is either broadcast or drilled directly on plant beds. The seeds are small, the 1000-seed weight being about 0.3 g. A seed rate of 8 kg/ha is recorded as adequate. Before sowing, the seed is mixed with sand or finely sieved soil to achieve a uniform spread and good plant establishment. Broadcasting the seed is preferred for leaf produc-

tion. Plants are thinned to a spacing of about 15 cm; they become very bushy with overhanging branches at wider spacings. Drilling in rows spaced 0.8–1.0 m apart is more suitable for seed production.

Management *Celosia trigyna* requires fertile soils for proper growth. In poor or moderately fertile soil, incorporation of organic manure at a rate of 20–25 t/ha before planting is recommended. As an alternative, application of NPK (20–10–10) at 300–400 kg/ha is suitable for a single harvest by uprooting, whereas in case of repeated cutting a higher dose of 500–700 kg/ha can be applied. Weeding is essential at the early seedling stage and regular watering is required during dry periods.
Celosia trigyna often becomes weedy in other crops. It can be controlled fairly easily both mechanically and with herbicides.

Diseases and pests Disease incidence is not common in *Celosia trigyna* and no records of serious diseases are available. Insect pests recorded include millipedes and the adults and nymphs of the tortoise beetle (*Cassida tosta*), which feed on the leaves. In south-western Nigeria, a few destructive insects have been recorded on the plant. Adults of *Gasteroclisus rhomboidalis* attack the stem, and the leaves are attacked by adults of *Anacatantops notatus*. The larvae of *Sceliodes laisalis* and *Hymenia recurvalis* are destructive to the leaves.

Harvesting *Celosia trigyna* can be harvested either by uprooting of young and vigorous seedlings or by repeated cutting. The first leaf harvest is about 8 weeks after sowing and up to 8 pickings of young shoots are possible in a period of 2 months before flowering reduces growth. Cutting of side branches and stems at 5 cm above soil level encourages branching.

Yield Weekly harvest for a period of up to 2 months can yield about 4–5 t/ha of fresh vegetable.

Handling after harvest Fresh leaves are used for home consumption or marketing directly after the harvest or dried for later use. Fresh stem and branches are tied into small bundles before they are taken to the markets for sale.

Genetic resources Diversity within *Celosia trigyna* is considerable, but there is no information on attempts to collect, conserve and characterize the diversity. Improved cultivars are not available. There is no threat of genetic erosion in wild populations because *Celosia trigyna* is widespread and common in disturbed habitats.

Prospects *Celosia trigyna* is currently of little importance as a leafy vegetable in comparison with *Celosia argentea*, but availability of genetically improved types and suitable agronomic practices could rapidly increase the production as a tasty leafy vegetable.

Major references Burkill, H.M., 1985; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Mander, M., 1998; Townsend, C.C., 1985; Townsend, C.C., 1988; Townsend, C.C., 2000; van Epenhuijsen, C.W., 1974.

Other references Akinlosotu, T.A., 1983; Badra, T., 1993; Cavaco, A., 1974; Dupriez, H. & De Leener, P., 1989; Eluwa, M.C., 1977; Gbile, Z.O., 1983; Lowe, J. & Soladoye, M.O., 1990; Townsend, C.C., 1975; Townsend, C.C., 1993.

Sources of illustration Townsend, C.C., 1975.

Authors O.A. Denton

CERATOPTERIS THALICTROIDES (L.) Brongn.

Protologue Bull. Sci. Soc. Philom. Paris, sér. 3, 8: 186, t. 3–4 (1821).

Family Pteridaceae

Chromosome number n = 77, 78, 80; $2n$ = 154, 156

Synonyms *Acrostichum thalictroides* L. (1753), *Ceratopteris cornuta* (P.Beauv.) Lepr. (1830).

Vernacular names Water sprite, swamp fern, floating stag's horn, Sumatra fern, Indian fern, oriental water fern (En). Fougère de Sumatra, fougère aquatique flottante (Fr).

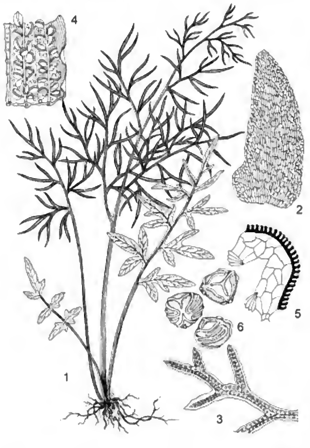
Origin and geographic distribution *Ceratopteris thalictroides* is found worldwide in the lowland tropics especially of the Old World. It is found throughout African coastal lowland, and is especially common in West African estuaries and swamps.

Uses The only record of *Ceratopteris thalictroides* being eaten in Africa is from Madagascar, where it is used in a similar way as watercress. It is commonly eaten throughout South-East Asia. In Malaysia and Japan it is an established luxury vegetable. The young leaves, before they have uncurled, make excellent greens and when cooked or blanched they can be eaten as a salad.
The plants can be used as a green manure in rice fields. Medicinally, this fern (both leaf and root) is used in Malaysia and the Philippines as a poultice against skin complaints, e.g. as a drawing agent on carbuncles, in China as a

styptic to stop bleeding. *Ceratopteris* species, including *Ceratopteris thalictroides*, are grown as ornamentals in aquariums, popularly called 'water sprite'. *Ceratopteris thalictroides* and especially also *Ceratopteris richardii* Brongn. serve as model plants in developmental biology and molecular research. They are useful for research because they have independent haploid and diploid life phases, a short life cycle, a simple genetic system, and reproduce by single-celled haploid spores.

Properties Alkaloids, arbutin and tannin have been found in the green parts of *Ceratopteris thalictroides*.

Botany Aquatic or semi-aquatic fern, up to 1 m tall, floating or rooted in soil, with short, erect rhizome and rosette-like tuft of leaves. Leaves dimorphous; sterile leaves with succulent petiole 5–50 cm long, sparsely scaly with broad, pale brown scales, filled with air canals, lamina of sterile leaves 1–3-pinnate, up to 20 cm × 40 cm, membranous, glabrous, with evident anastomosing veins, often provided with adventitious buds in axils of pinnae, pinnae irregularly shaped, ultimate lobes linear-oblong to elliptical; lamina of fertile leaves erect, 2–4-divided, up to 100 cm × 50 cm, ultimate lobes linear, margin revolute, covering the sporangia scattered individually along the veins. Spores tetrahedral, 95–125 μm in diameter, pale yellow, translucent, with irregular reticulum.



Ceratopteris thalictroides – *1, habit; 2, petiole scale; 3, fertile part leaf segment; 4, sporangia along veins; 5, sporangium; 6, spores.*
Source: PROSEA

Ceratopteris is often classified in *Parkeriaceae*, a family included in *Pteridaceae* here. *Ceratopteris thalictroides* is morphologically very variable. If grown under water, as in aquariums, the lamina of the submersed (sterile) leaves are finely 3–4-pinnate, with ultimate lobes linear.

Ecology *Ceratopteris thalictroides* is a floating or loosely rooted aquatic fern. It grows in swampy areas, swamp forests, marshes, natural and man-made ponds, mostly in stagnant water bodies or in still pockets along slow flowing rivers, from sea-level to 1300 m, but mostly below 500 m altitude. It occurs in full sun to moderate shade, sometimes massed on or around logs or other floating vegetation.

Management *Ceratopteris thalictroides* has a very short life cycle. The whole cycle from spore to spore can be completed in less than 30 days. Apart from spores, the plant reproduces by bulbils growing on the leaves. In Japan and South-East Asia *Ceratopteris thalictroides* is sometimes cultivated for food, but rarely commercially. Farmers harvest the plants from rice fields and swampy locations for local consumption. In aquarium culture the mother plants are normally split in 3-leaf segments, but any part of the leaf if left floating in the water will give rise to new plantlets.

Genetic resources and breeding *Ceratopteris thalictroides* is distributed throughout the tropics and is not in danger of genetic erosion or extinction. In Africa, the programmes to conserve the natural wetlands will help the species to maintain its genetic diversity. Germplasm collections or breeding programmes are not known to exist, also because it is considered a weed in rice fields.

Prospects The fact that *Ceratopteris thalictroides* plants are eaten as a vegetable in Asia and Madagascar indicates a possible similar use for the African continent. It seems worthwhile investigating this potential further. Studies should include the nutritional value, possible negative health indications, unknown local uses, the environmental impact of large-scale gathering from the wild, as well as possibilities for commercial production.

Major references Burkill, H.M., 2000; Copeland, E.B., 1942; Decary, R., 1946; Chan-

pen Prakongvongs, 2003.

Other references Alston, A.H.G., 1959; Benedict, R.C., 1909; Javalkegar, S.R., 1960; Klekowski, E.J., 1970b; Lloyd, R.M., 1972; Lloyd, R.M., 1974; Masuyama, S. & Watano, Y., 1994; Pal, N. & Pal, S., 1969; Schelpe, E.A.C.L.E., 1970a; Tardieu-Blot, M.L., 1964a.

Sources of illustration Chanpen Prakongvongs, 2003.

Authors W.J. van der Burg

Based on PROSEA 15(2): Cryptogams: Ferns and fern allies.

CERATOTHECA SESAMOIDES Endl.

Protologue Linnaea 7: 5, t. 1–2 (1832).

Family Pedaliaceae

Chromosome number $2n = 32$

Synonyms *Ceratotheca melanosperma* Hochst. ex Bernh. (1842), *Sesamum heudelotii* Stapf (1906).

Vernacular names False sesame (En). Faux sésame (Fr). Lalo-caminho (Po). Mlenda, mlenda wa sege (Sw).

Origin and geographic distribution *Ceratotheca sesamoides* is indigenous in Africa and occurs wild in most countries south of the Sahara. It is locally cultivated.

Uses The leaves and flowers of false sesame are consumed as a vegetable. The leaves are finely chopped and used in sauces. They are also pounded and mixed with groundnut flour, salt and a little hot water and cooked for a few minutes. The mixture is eaten as a sauce with porridge; warm milk may be used instead of water. Ash may be added to soften the leaves and to reduce bitterness. Onions and tomatoes may also be added. The seeds are crushed to form a paste that is eaten with beans or cassava. They are also crushed for their oil, which is especially suited as salad oil.

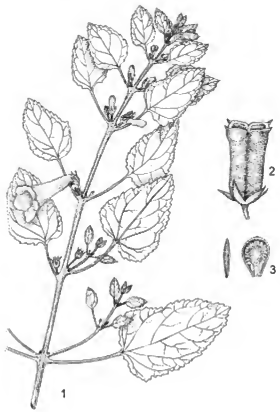
Ceratotheca sesamoides – wild and planted

Adding leaf sap of false sesame to the boiling seed pulp of *Vitellaria paradoxa* C.F.Gaertn. while making shea butter aids the separation of fat. A decoction of the plant is used against diarrhoea. Leaves are steeped in water and the slimy liquid is dropped into the eye to treat conjunctivitis. The mucilage is occasionally used as an emollient and lubricant. A leaf maceration facilitates delivery in humans and animals. Leaves are warmed, ground, mixed with ash and rubbed on inflamed cervical lymph nodes. Leaves ground with the rhizome of *Anchomanes difformis* (Blume) Engl. are applied topically in cases of leprosy. False sesamum is also reported to be used as an aphrodisiac, against jaundice, snakebites and skin diseases. The plants are eaten by camels, cattle, goats and sheep.

Properties The nutritional composition of fresh leaves of false sesame per 100 g is: water 81 g, energy 226 kJ (54 kcal), protein 4.2 g, fat 0.5 g, carbohydrate 11.0 g, Ca 300 mg, P 86 mg, Fe 3.2 mg, ascorbic acid 28 mg. The nutritional composition of the seed is: water 7.0 g, energy 2303 kJ (550 kcal), protein 14.2 g, fat 46.5 g, carbohydrate 27.5 g, Ca 887 mg, Fe 38 mg, thiamin 0.75 mg, riboflavin 0.3 mg, niacin 4.4 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). The seed oil is similar in composition to sesame oil. It contains the phenylpropanoid lignan sesamin. This compound showed antioxidant, anti-inflammatory, antihypertensive, cytotoxic (including antitumour) and insecticidal activities.

Adulterations and substitutes Wild species of *Sesamum* often replace *Ceratotheca sesamoides* as a vegetable.

Description Annual herb up to 100(–120) cm tall, sometimes with woody rootstock, with prostrate, ascending or erect, pubescent stems. Leaves opposite or nearly opposite, simple; stipules absent; petiole up to 6 cm long in lower leaves, very short in upper leaves; blade lanceolate-deltate to ovate-triangular or narrowly ovate, 1.5–8 cm × 0.5–4.5 cm, truncate, broadly cuneate or slightly hastate at base, acute at apex, usually coarsely toothed at least toward base, pubescent and densely glandular below, sparsely so above, palmately veined at base. Flowers solitary in leaf axils, bisexual, zygomorphic, 5-merous; pedicel 3–8 mm long; calyx with narrowly triangular lobes up to 7



Ceratotheca sesamoides – 1, flowering branch; 2, fruit; 3, seeds.
Redrawn and adapted by Iskak Syamsudin

mm long, connate at base; corolla funnel-shaped, 1.5–4 cm long, sparsely pubescent, pink, lilac, mauve or purple, throat and lower lobe often cream with dark lines, lower lobe broadly ovate and longer than other lobes; stamens 4, inserted near base of corolla tube and included; ovary superior, 2-celled but each cell almost to apex divided by a false septum, style long and slender, with 2-lobed stigma. Fruit an oblong-quadrangular capsule 1–2 cm long, compressed laterally, with slender lateral horns up to 3.5 mm long, loculicidally dehiscent, many-seeded. Seeds broadly obovate in outline, compressed laterally, 2.5–4 mm × 2–2.5 mm, testa smooth but radially rugose at margin, usually black when ripe. Seedling with epigeal germination; hypocotyl 1.5–4.5 cm long; cotyledons broadly elliptical, up to 1 cm long, entire, leafy.

Other botanical information *Ceratotheca* comprises 5 species, all native to Africa. It is related to *Sesamum*, but *Sesamum* fruits lack lateral horns.

Ceratotheca sesamoides and other *Pedaliaceae* are covered with mucilage glands. The mature secreting glandular hair consists of a head of 4 cap cells, which are attached to a stalk of 1–3 cells. The glands may enable the plant to withstand severe desiccation without tissue death. After contact with water, the outer cell walls of the head cells dissolve, producing an enormous amount of mucilage.

Ceratotheca triloba (Bernh.) Hook.f. occurs in southern Africa. It is used medicinally and grown as an ornamental, and occasionally, e.g. in Zimbabwe, it is used as a leafy vegetable in times of shortage when tastier vegetables are not available.

Growth and development The stems of false sesame are usually prostrate; each plant produces 10 or more creeping stems. The regular removal of young shoots permits sustained vegetative growth and flowering, prolonging the productive period. *Ceratotheca sesamoides* is primarily self-pollinated; the flowers open at dawn, after pollination has occurred. It takes about 6 weeks from anthesis to fruit maturity.

Ecology *Ceratotheca sesamoides* shows a wide range of adaptability and environmental flexibility. It occurs as a weed and in formerly cultivated fields, particularly on well-drained sandy soils and in localities well exposed to the sun. It tolerates heat and drought well. Under more natural conditions it occurs in open grassland and tree savanna on sandy soils, rarely in rocky localities.

Propagation and planting False sesame is mainly a protected weed, but locally, e.g. in northern Uganda, it is sown in fields and intercropped with okra, eggplant, cowpea, amaranth, sorghum, sweet potato and sesame. Seed is broadcast at the onset of rains. It does not show dormancy.

Management Apart from some weeding little care is given to false sesame.

Diseases and pests In Burkina Faso false sesame is recorded as one of the vegetables most tolerant to diseases and pests.

Harvesting For vegetable use, young tender stems are picked. Flowers are also included, but fruits are avoided.

Handling after harvest The smaller leaves at the stem apex are selected for cooking. Leaves may be preserved by drying.

Genetic resources It seems unlikely that false sesame is threatened by genetic erosion, since it is weedy and becoming domesticated in parts of Africa. A collection from western Sudan was deposited at the Agricultural Research Corporation, Wad Medani, Sudan.

Prospects There seems to be a resurgence of interest in using *Ceratotheca sesamoides*,

which is reflected in its domestication in parts of Africa.

Major references Abels, J., 1975; Bedigian, D., in press; Bruce, E.A., 1953; Burkill, H.M., 1997; Busson, F., 1965; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Neuwinger, H.D., 2000; Seignobos, C., 1982; Smith, G.C. et al., 1996; Stevels, J.M.C., 1990.

Other references Adjanohoun, E.J.A., 1986; Bedigian, D., 2003b; Bedigian, D., Seigler, D.S., & Harlan, J.R., 1985; Bedigian, D. & van der Maesen, J., 2003; Delisle, H. et al., 1997; Dokosi, O.B., 1998; Glegg, C.G., 1945; Hakki, M.I., 1984; Ihlenfeldt, H.-D., 1988; Irvine, F.R., 1969; Katende, A.B., Ssegawa, P. & Birnie, A., 1999; Manning, S.D., 1991; Mertz, O., Lykke, A.M. & Reenberg, A., 2001; Ogle, B.A. et al., 1990; Tindall, H.D., 1965; Verboom, W.C., 1973; Williamson, J., 1955.

Sources of illustration Stevels, J.M.C., 1990.

Authors D. Bedigian & O.A. Adetula

CERCESTIS MIRABILIS (N.E.Br.) Bogner

Protologue Aroideana 8(3): 73 (1986).

Family Araceae

Synonyms *Rhektophyllum mirabile* N.E.Br. (1882), *Nephtytis picturata* N.E.Br. (1887), *Rhektophyllum congense* De Wild. & T.Dur. (1901).

Origin and geographic distribution *Cercestis mirabilis* occurs from Benin to Uganda and Angola.

Uses In Gabon the young leaves and inflorescences are eaten as a vegetable. The leaves are cooked in butter from moabi (*Baillonella toxisperma* Pierre) nuts together with an unspecified fungus, and eaten to treat liver complaints and stitch. The leaves may also be combined with the bark of various trees, the rhizome of *Sarcophrynium* species and seeds of chilli for the same ailments. In Congo leaf-sap is taken in draught with kaolin, melegueta pepper (*Aframomum melegueta* K.Schum.) and rock salt to treat heart troubles and to stop vomiting.

The long pendulous roots of *Cercestis mirabilis* are used in southern Nigeria as ties for yams, and in Gabon the central fibrous core of these roots is used as fishing line.

Botany Large herbaceous climber; stem climbing by clasping roots, up to 5 cm in diameter, also with flagelliform shoots having long slender internodes and reduced leaves. Leaves alternate, simple; petiole up to 1 m long; blade hastate-sagittate in outline, up to 100 cm × 60 cm, deeply and irregularly pinnatifid with truncate trapezoid lobes. Inflorescence a spadix 7–17 cm × 1–2 cm, enclosed by a spathe 6–15 cm × 2–3 cm in diameter, dull green outside with reddish tinge at base, whitish green inside, 2–8 together in leaf axils; peduncle 2–4.5 cm long. Flowers unisexual, sessile; male ones in upper part of spadix, with 2–4 free creamy white stamens; female ones in basal part of spadix, with obovoid, 1-celled ovary, stigma discoid. Fruit a pyramid-shaped berry, c. 1 cm × 2 cm, red when ripe.

Cercestis comprises 13 species and is restricted to tropical Africa, from Gambia and Senegal to Uganda and Angola. *Cercestis camerunensis* (Ntépé) Bogner, occurring from Nigeria to Gabon, can easily be confused with *Cercestis mirabilis*. The uses described above may therefore be equally applicable to *Cercestis camerunensis*.

Ecology *Cercestis mirabilis* occurs in lowland humid forest, up to 400 m altitude.

Management The young leaves are taken from the extremities of side branches, leaving the main stem intact. Mature leaves and stems are harvested for medicinal purposes, but usually part of the main stem will remain, which then easily recovers with new shoots.

Genetic resources and breeding No germplasm collections are known to exist. *Cercestis mirabilis* is harvested from the wild, but it is not used on a commercial scale. It is quite common in its range of distribution, and because the plant can recoup from partial harvesting, no special precautions for its protection need to be taken.

Prospects *Cercestis mirabilis* is of limited importance as a vegetable and medicinal plant. Research on nutritive composition and active constituents is needed to evaluate its uses.

Major references Bouquet, A., 1969; Burkill, H.M., 1985; Ntépé-Nyame, C., 1988; Raponda-Walker, A. & Sillans, R., 1961; Raponda-Walker, A., 1952.

Other references Bogner, J., 1986; Bogner, J. & Nicolson, D.H., 1991; Mayo, S.J., Bogner, J. & Boyce, P.C., 1997.

Authors W.J. van der Burg

CEROPEGIA PAPILLATA N.E.Br.

Protologue Bull. Misc. Inform. Kew 1898: 308 (1898).

Family Asclepiadaceae (APG: Apocynaceae)

Synonyms *Ceropegia cordiloba* Werderm. (1939).

Origin and geographic distribution *Ceropegia papillata* occurs in eastern Africa south of the equator, e.g. in Tanzania and Malawi.

Uses The tuberous roots and the raw leaves are eaten by boys in the Kota Kota Hills of Malawi. The tubers contain much water and are eaten against thirst in dry regions. Potentially, *Ceropegia papillata* is an ornamental climber.

Properties Numerous *Ceropegia* species have edible tubers. *Ceropegia multiflora* Bak., for example, has tubers containing per 100 g: water 95 g, energy 65 kJ (15 kcal), protein 0.8 g, fat 0.03 g, carbohydrate 3 g, fibre 0.3 g (Arnold, T.H., Wells, M.J. & Wehmeyer, A.S., 1985).

Botany Twining, pubescent herb about 1 m long, arising from a globose tuber, stem 1–2 mm in diameter. Leaves opposite, simple, herbaceous; petiole up to 2.5 cm long; blade oblong-ovate, 3–6 cm × 1–2.5 cm, base cordate, apex long-acuminate, margin entire, hairy on both sides. Inflorescence a subsessile umbel-like cyme, 10–20-flowered. Flowers bisexual, regular, 5-merous, white; pedicel 8–10 mm long, pubescent; sepals linear-lanceolate, 6 mm × 1–2 mm; corolla tubular, 2.5 cm long, straight, tube with basal part ovoid-inflated, dull green, strongly papillate along the veins inside, upper part cylindrical, 1.5 mm in diameter, whitish green, glabrous, lobes linear, 4–8 mm × 1.5 mm, connate at the tips, replicate, villous with rather long white hairs within, the margins and the apical half blackish-green; outer corona cup-shaped at base with lobes c. 1.5 mm long, or entirely cup-shaped, white; inner coronal lobes linear, 1–1.5 mm long, white; stamens united into a staminal column c. 1.5 mm long, anthers oblong, leaning on the truncate apex of the style.

Two varieties have been distinguished based on the form of the outer corona: in var. *papillata* the lobes of the outer corona are only connate at the base; in var. *cordiloba* (Werderm.) H.Huber they are completely connate forming a cup which is crenate-denticulate at apex.

Ecology *Ceropegia papillata* grows in mountainous areas at 1350–2000(–3000) m altitude. It often climbs in shrubs, in rocky or grassy locations. In Malawi and Tanzania it flowers in February–May.

Genetic resources and breeding *Ceropegia papillata* is a rare species in mountainous areas in need of protection.

Prospects Because *Ceropegia papillata* is a rare species collecting this vegetable from the wild cannot be recommended. More research is necessary to determine the nutritive value of the leaves and tubers, and possibilities for its cultivation as a vegetable and ornamental.

Major references Arnold, T.H., Wells, M.J. & Wehmeyer, A.S., 1985; Bally, P.R.O., 1976; Huber, H., 1957; Werdermann, E., 1939.

Other references Brown, N.E., 1902–1904; Williamson, J., 1955.

Authors P.C.M. Jansen

CHENOPODIUM ALBUM L.

Protologue Sp. pl. 1: 219 (1753).

Family Chenopodiaceae (APG: Amaranthaceae)

Chromosome number $2n$ = 36, 54

Vernacular names White goosefoot, pigweed, lamb's quarters, lambsquarters (En). Chénopode blanc, ansérine blanche (Fr). Catassol (Po).

Origin and geographic distribution *Chenopodium album* is mainly known as a noxious weed with global distribution, occurring from 70°N to 50°S, including all African countries; in the tropics mostly at higher altitudes. Already in prehistoric times seed was harvested for human consumption in both the Old and the New World. *Chenopodium album* has been domesticated in the Himalayan region, where it is grown as a grain crop in Nepal and northern India. In India it is also cultivated as a traditional leafy vegetable.

Uses Young shoots and leaves of *Chenopodium album* are occasionally used as a vegetable, sometimes as a famine food. In southern Africa it is considered a popular wild vegetable. The young shoots are boiled and eaten alone or mixed with other vegetables. They may also be dried and stored for later use.

In isolated hill communities inhabiting the montane zone of the middle Himalayan range *Chenopodium album* is a subsistence food crop. The seed is processed into flour for pancakes and bread. It is boiled and mixed with other ingredients to make a kind of gruel, or is roasted and ground for porridge, and is also used for preparing fermented and alcoholic

beverages. The seed is also used as poultry and livestock feed. Medicinally, the seed of *Chenopodium album* has been used tradionally to improve the appetite and as an anthelmintic, laxative, aphrodisiac and tonic; they are also thought to be useful in biliousness, abdominal pains, eye diseases, throat troubles, piles and diseases of blood, heart and spleen.

Properties The nutritional composition of *Chenopodium album* leaves per 100 g edible portion is: water 84 g, energy 184 kJ (44 kcal), protein 4.3 g, fat 0.8 g, carbohydrate 7.3 g, fibre 2.1 g, Ca 280 mg, P 81 mg, vitamin A 11,300 IU, thiamin 0.15 mg, riboflavin 0.4 mg, niacin 1.3 mg, ascorbic acid 90 mg (Rubatzky, V.E. & Yamaguchi, M., 1997).
The nutritional composition of seed of Himalayan cultivars per 100 g is: energy 1654 kJ (395 kcal), protein 16 g, fat 7 g, carbohydrate 66 g (Partap, T., Joshi, B.D. & Galwey, N., 1998). Seed of the weedy types of *Chenopodium album* (in Africa and elsewhere), however, is probably of inferior quality and less nutritious. An ethanolic extract of the fruits has shown antipruritic and antinociceptive activities in tests with mice.

Botany Erect annual herb up to 1.5(–4) m tall; young vegetative parts densely clothed with mealy-white or red-purple vesicles; stem angular, ribbed, with longitudal dark green or red streaks. Leaves alternate, simple; stipules absent; lower leaves with long petioles, ovate-rhomboid, irregularly and coarsely toothed or incised, higher ones gradually with shorter petioles, elliptical-oblong-lanceolate, less deeply incised or entire; blade 1.5–18 cm × 0.5–18 cm. Inflorescence a large, axillary and terminal, leafy panicle, consisting of clusters of flowers. Flowers bisexual, regular, 5-merous; tepals connate at base; stamens opposite tepals; ovary superior, depressed globose, 1-celled, style short, stigmas 2. Fruit a nut, entirely enclosed by the incurved tepals, thin-walled, indehiscent, 1-seeded. Seed nearly smooth, lenticular, 1–2 mm in diameter, testa thinly leathery, blackish-brown; embryo annular, surrounding the endosperm. Seedling with epigeal germination; hypocotyl 2–7 cm long; cotyledons leafy, stalked; first pair of leaves opposite, subsequent leaves alternate.

Chenopodium album – 1, lower part of plant; 2, upper part of plant; 3, flower; 4, flower with 2 tepals removed; 5, fruit; 6, seed.
Source: PROSEA

Chenopodium is a large genus (100–150 species), mainly found in temperate zones throughout the world. Some species have naturalized in the mountainous regions of the tropics. *Chenopodium album* consists of a very variable polyploid weed complex. In the montane zone of the central Himalayan region types selected from this complex are now cultivated for their seeds and for their leaves. The cultivars grown for the seeds can be distinguished from wild plants by their usually taller habit (up to 4 m), a large, leafless, exserted, compact and drooping inflorescence with bisexual and female flowers, and non-shattering, larger seed.
In Africa some other wild *Chenopodium* species are used as vegetables in a similar way as *Chenopodium album*. In Madagascar and Zambia *Chenopodium giganteum* D.Don (synonym: *Chenopodium amaranticolor* (Coste & Reyn.) Coste) (purple goosefoot, tree spinach) is considered an excellent cooked vegetable. It is closely related to *Chenopodium album*, but also to *Chenopodium quinoa* Willd. (quinoa), cultivated as a grain crop in South America, and its taxonomy is still unclear.
In southern Africa young parts of *Chenopodium murale* L. (nettle-leaved goosefoot) are used as a cooked vegetable, and in West Africa they are sometimes used in sauces. The plant is said to be a good forage although in Australia poisoning of livestock has been reported. In Morocco the seeds are eaten as a famine food.

Chenopodium murale much resembles *Chenopodium album*, but differs in its rhombic-ovate leaves with numerous teeth, clearly cymose inflorescences and sharply keeled, closely pitted seeds.
The leaves of *Chenopodium opulifolium* Schrad. ex Koch & Ziz (grey goosefoot) are eaten as a cooked vegetable in Tanzania. The plant is also considered a good forage and sometimes it is cultivated as an ornamental. It is very similar to *Chenopodium album*, but differs in its broader leaves and usually more glaucous mealy inflorescence.

Ecology The wide distribution of *Chenopodium album* as a weed points to a broad tolerance of climates with average temperatures ranging from 5–30°C. It tolerates night frost. In Africa and elsewhere it is a weed of cultivated and disturbed localities, usually occurring above 1000 m altitude. In the long days of the temperate and subtropical zones it grows to a large size and it is there that it offers the most serious competition to crops.

Management In Africa young shoots and leaves of *Chenopodium album* are collected from the wild. Cultivation and use as a subsistence seed crop is limited to an estimated 1500 ha in the Himalayas. Grain chenopods are commonly sown 1–2 cm deep in rows 25–50 cm apart depending on soil moisture content and expected rainfall. The 1000-seed weight is about 1.4 g. Seed rate is 6–10 kg/ha, resulting in 100–150 plants per m^2. The seedbed should be well prepared. The seed may also be broadcast, but it is easier to weed when sown in rows. Broadcasting requires about 20 kg of seed per ha. Seedlings will emerge in approximately one week in a sufficiently moist soil with an average temperature above 10°C. The period between sowing and flowering and from flowering until maturity of the seed is very variable. Early and daylength-neutral cultivars may take 50–60 days to flowering and 90–110 days to seed maturity, whereas late and short-day cultivars need 4–5 weeks longer. Grain chenopods are predominantly self-pollinating; cross pollination is less than 10%. In Himachal Pradesh (India), *Chenopodium album* is often intercropped, e.g. with finger millet, potato, maize, rice, amaranth, foxtail millet, sesame, soya bean, taro, cowpea or common bean. The most important disease is downy mildew (*Peronospora farinosa* f.sp. *chenopodii*), which causes much damage in chenopod growing areas all over the world. The disease is favoured by warm and humid weather. Some cultivars are partially resistant. Other fungal diseases may also cause serious damage, as well as insect pests, of which the leaf miner or leaf sticker *Eurisaca melanocompta* is the most serious. Birds attacking the crop before harvesting or during field drying probably cause the greatest crop losses. Bitter cultivars are less prone to such attacks than sweet ones. Harvesting methods used for cereals can also be used for grain chenopods. Plants are cut, bundled and dried, threshed, and the seed is winnowed. Yields of 0.2–0.6 t/ha are reported from farmers' fields in India. One reason for low yields may be that grain chenopods are not often grown alone but are usually intercropped. Inflorescences do not dry easily. At harvest, seed moisture content may be around 20%, and artificial drying to 14% moisture may be necessary.

Genetic resources and breeding Wild *Chenopodium album* is widespread and not in danger of genetic erosion. Germplasm collection of cultivars is urgently needed, since their cultivation in the Himalayas is definitely declining as a result of lack of crop improvement, and farmers are turning to other, more profitable crops.

Prospects In Africa *Chenopodium album* will remain a minor leaf vegetable and in many regions it is considered a weed rather than a useful plant. The possibilities for cultivation of seed cultivars at higher altitudes are worthwhile investigating.

Major references Brenan, J.P.M., 1988; Decary, R., 1946; Mastebroek, H.D., van Soest, L.J.M. & Siemonsma, J.S., 1996; Ruffo, C.K., Birnie, A. & Tengnäs, B., 2002; van Wyk, B.E. & Gericke, N., 2000.

Other references Aellen, P., 1959–1979; Brenan, J.P.M., 1954; Brenan, J.P.M., 1964; Burkill, H.M., 1985; Jansen, P.C.M., 1981; Partap, T., Joshi, B.D. & Galwey, N., 1998; Rubatzky, V.E. & Yamaguchi, M., 1997.

Sources of illustration Mastebroek, H.D., van Soest, L.J.M. & Siemonsma, J.S., 1996.

Authors P.C.M. Jansen

CICHORIUM ENDIVIA L.

Protologue Sp. pl. 2: 813 (1753).
Family Asteraceae (Compositae)
Chromosome number $2n = 18$
Vernacular names

- Broad-leaved types: Escarole, broad-leaved endive (En). Scarole, chicorée scarole (Fr). Chicória escarola (Po).

– Narrow-leaved types: Endive, curly endive (En). Frisée, chicorée frisée (Fr). Chicória frisada (Po).

Origin and geographic distribution *Cichorium endivia* is only known from cultivation. It was probably first brought into cultivation in the Mediterranean region, where its wild relatives *Cichorium pumilum* Jacq. and *Cichorium calvum* Sch.Bip. ex Asch. occur. Both species can be considered as the progenitor of escarole and endive. *Cichorium endivia* was probably known to the old Egyptians, but no archaeological evidence has been found. It spread to central Europe in the 16th century and is now grown throughout Europe and North America. It is grown throughout the tropics including tropical Africa, but is mostly of minor importance there.

Uses Endive is most commonly eaten as a fresh green in salads, for which curly-leaved types are often preferred. Plants for salads are sometimes blanched to reduce bitterness. Endive is used as a substitute for lettuce in the tropics as it is more resistant to diseases. Broad-leaved types (escarole) are also used as a cooked vegetable. *Cichorium endivia* is sometimes used in making pickles, but is otherwise not used in a processed form.

Production and international trade The main area of production is the European Union where 530,000 t was produced from 26,000 ha in 1985, followed by North America with about 50,000 t. No statistics are available for other areas.

Properties The nutritional composition of escarole per 100 g edible portion is: water 94 g, energy 71 kJ (17 kcal), protein 1.3 g, fat 0.2 g, carbohydrate 3.4 g, fibre 3.1 g, Ca 52 mg, Mg 15 mg, P 28 mg, Fe 0.8 mg, Zn 0.8 mg, vitamin A 2167 IU, thiamin 0.08 mg, riboflavin 0.08 mg, niacin 0.4 mg, folate 142 μg, ascorbic acid 6.5 mg (USDA, 2002). The nutritional composition of endive is about the same, except for the ascorbic acid content, which is 13 mg per 100 g. *Cichorium endivia* contains inulin and intybin, which cause the typically bitter taste and which are said to stimulate appetite. More than 100 volatile compounds have been identified; among them hexenal, (E)-2-hexenal and β-ionone, contributing intense odour notes.

Description Annual or biennial, erect herb up to 170 cm tall, with taproot containing bitter milky juice, producing a rosette of large leaves when young, these forming a loose head. Leaves alternate, simple or pinnatifid, sessile, broad, up to 45 cm × 18 cm, slightly crumpled, margin entire or dentate (escarole type) or very narrow, deeply pinnatifid and strongly curled (curly-leaved type), progressively smaller upwards on stem, slightly pubescent or glabrous, pale to dark green or yellowish, sometimes reddish along midrib. Inflorescence a head, 1–6 together, sessile or on up to 20 cm long, apically thickened peduncle; involucre with outer row of 5 bracts 7–10 mm × 2–5 mm, and inner row of 8 bracts 8–12 mm × 1–3 mm. Flowers 15–20 per head, all ligulate; corolla up to 2 cm long, blue, sometimes white, 5-lobed at apex; stamens 5 with anthers fused into a tube; ovary inferior, 1-celled, style slender, hairy, with 2 slender stigmatic lobes. Fruit an obovoid to cylindrical achene 2–3 mm × 1–1.5 mm, brown, with pappus of 1–3 rows of small, persistent membranous scales.

Cichorium endivia – 1, plant habit; 2, leaf of endive; 3, leaf of escarole.
Source: PROSEA

Other botanical information *Cichorium* comprises 6 species and occurs naturally in Europe, northern Africa, and western and central Asia. Two species are commonly cultivated (also in tropical Africa): *Cichorium endivia*, which is not known from the wild, and *Cichorium intybus* L. (chicory), which is grown for its roots used as a coffee surrogate, forage and as a source of inulin (fat replacer), and as a

leafy vegetable (witloof and radicchio) popular in Europe. These two species are often confused as they are morphologically very similar, but they differ in life span and reproductive system (*Cichorium intybus* is a self-incompatible perennial), whereas DNA-based analytical methods did not support a close relation.

Three cultivar-groups are distinguished within *Cichorium endivia*:

- Batavian Group (has also been called Escarole Group, Scarole Group or var. *latifolium* Lam.): with broad, almost entire, rather flat leaves, forming a loose head; some well-known cultivars are 'Batavian Broad-Leaved', 'Escarole', 'Deep Heart Fringed', 'Growers Giant' and 'Géante maraîchère'.
- Curled-leaved Group (has also been called Curled Endive Group, Frisée Group or var. *crispum* Lam.): with narrow, deeply pinnatifid, strongly curled leaves, forming a loose head; some well-known cultivars are 'Salad King', 'Green Curled', 'Frisée de Ruffec' and 'Grosse Pancalière'.
- Cutting Group (has also been called Small Endive Group, Endivia Group or var. *endivia*): with very small leaves that do not form a head; cultivars belonging to this group are hardly grown anymore.

Growth and development *Cichorium endivia* forms a dense rosette of leaves in the first year. Upon bolting the stem elongates and branches. The inflorescence bears many heads. Flowers are usually open in the morning only and wither after about 6 hours. Most cultivars are self-pollinating but some cross-pollination by insects may occur.

Ecology Escarole and endive are easy to cultivate. They are more tolerant of high temperatures than lettuce and can be grown from cool temperate areas to tropical lowlands, though in the tropics better results are obtained above 500 m altitude. The mean daily optimum temperature for growth is 15–18°C. Mild frost is tolerated. At high temperatures leaves may become fibrous. *Cichorium endivia* requires long days for flowering and rarely flowers in the tropics. Vernalization (in some cultivars at temperatures below 15°C) gives an additional stimulus to flowering and can occur already during ripening of the seed, but also during storage of seed and from sowing onwards.

Escarole and endive prefer a loose, pervious soil, sufficiently fertile, especially in the top 20 cm, with a pH of 6.5–7.8.

Propagation and planting Cultivation of escarole and endive is similar to that of lettuce, but generally less demanding. They require a deeply tilled soil and a friable seed-bed. They are propagated by seed. If sown in a nursery, seedlings are transplanted about 1 month after sowing, when they have 4–6 leaves. Direct sowing is practised as well. The 1000-seed weight is 1.3–1.6 g; about 0.5 kg/ha of seed is required. The planting distance is 25–40 cm × 25–40 cm, with the widest spacings for broad-leaved cultivars. Dense planting favours self-blanching, but increases the risk of rot.

Management Nitrogen requirements are moderate, heavy applications leading to strongly increased nitrate contents in the leaves and increased susceptibility to rotting. Phosphate requirements are high, those of potassium moderate, a crop of 12 t removing about 8 kg of P and 40 kg K. Mg deficiency may occur on acidic soils or where ample potassium is available, but can be corrected by spraying a 2% solution of magnesium sulphate.

An irregular supply of moisture may cause discoloration of the edges of younger leaves. The plants do not tolerate waterlogging.

Diseases and pests Diseases and pests are rarely serious. *Botrytis cinerea*, *Sclerotinia* spp. and various bacteria may cause 'bottom rot' (rot of the base of the plant), *Marssonina panattoniana* and *Alternaria cichorii* can cause leaf-spot, *Bremia lactucae* downy mildew. Escarole and endive are resistant to *Cercospora longissima*, which affects lettuce. Turnip mosaic virus (TuMV) and Endive necrotic mosaic virus (ENMV) may cause mosaic, yellowing and necrosis. Aphids and various caterpillars may also cause damage. Escarole and endive should not be planted after pulses, carrots, potatoes, garden beets and other composite crops, because of possible nematode build-up.

Harvesting Escarole and endive mature in 60–100 days from sowing. About a week before harvesting, heads may be tied up in order to blanch them and to moderate their bitterness. Blanching can also be achieved by covering each plant with a pot or container to exclude light (for about 10 days). There are self-blanching cultivars (especially when densely planted). Harvesting can start when heads have reached a marketable size (250–400 g). It is done by cutting the heads from the roots, removing the outer, discoloured or damaged leaves and placing the heads upside down in containers.

Yield Yields of 20 t/ha of marketable produce per crop can be attained.

Handling after harvest At ambient temperatures escarole and endive can be stored for only 1 day. When cooled to 0–1°C and at a humidity of 90–95%, healthy heads can be stored for up to 2 weeks. When grown in the tropics, they are often very bitter; this bitterness can be reduced by packing individual heads fairly tightly in plastic foil and storing them for 4–5 days in a refrigerator at 7°C.

Genetic resources Small collections of germplasm are kept by commercial breeders, at the Institut für Pflanzenbau und Pflanzenzüchtung, Braunschweig, Germany, and at the Vegetable Production Research Unit, USDA, Salinas CA, United States.

Breeding Little breeding work has been done. Commercial seed production is concentrated in Mediterranean countries.

Prospects Endive and less commonly escarole have a place in Western cuisine in the tropics, where they often complement or replace lettuce in salads. Their relative ease of cultivation, resistance to bolting and the availability of self-blanching cultivars favour their continued cultivation.

Major references Krug, H. et al., 1991; Martin, F.W. & Ruberté, R.M., 1975; Messiaen, C.-M., 1989; Nonnecke, I.L., 1989; Oyen, L.P.A., 1993; Rubatzky, V.E. & Yamaguchi, M., 1997; Ryder, E.J., 1999; Tindall, H.D., 1983; USDA, 2002a.

Other references Kiers, A.M., 2000; FCDB, 2002; Takeoka, G., 1999.

Sources of illustration Oyen, L.P.A., 1993.

Authors L.P.A. Oyen

Based on PROSEA 8: Vegetables.

CISSUS DINKLAGEI Gilg & Brandt

Protologue Bot. Jahrb. Syst. 46: 476 (1912).

Family Vitaceae

Origin and geographic distribution *Cissus dinklagei* is found from Cameroon to DR Congo, Gabon and Angola.

Uses The leaves of *Cissus dinklagei* are eaten in Gabon as a vegetable. The taste is acid, not unlike that of sorrel (*Rumex*) and *Cissus producta* Afzel. The cut stems exude copious, clear watery sap that is drunk in Gabon and in DR Congo. In Equatorial Guinea it is given to babies to stimulate their growth.

Properties No information is available on the chemical composition of *Cissus dinklagei*. Several other *Cissus* species, used in traditional medicine in South Africa, South America and Asia, have been the subject of investigation, and a wide range of compounds have been identified; several of these compounds showed anti-inflammatory, antispasmodic and antitumour activities.

Botany Liana with few, leaf-opposed, simple tendrils; stem cylindrical, up to 30 m long. Leaves alternate, simple; stipules oblong-triangular, early caducous, 4 mm × 2.5 mm; petiole 1–4 cm long; blade ovate to deltoid or elliptical, up to 10 cm × 6 cm, base truncate to subcordate, apex acuminate, margin entire. Inflorescence a cyme with umbel-like clusters, 4–10 cm long. Flowers bisexual, 4-merous; calyx cup-shaped, 1 mm long, toothed; petals c. 3 mm long, green; ovary superior, glabrous. Fruit an ovoid berry c. 3 cm × 2 cm, red, 1-seeded. Seed ovoid-oblong, compressed, up to 17 mm long.

The genus *Cissus* is closely related to *Cyphostemma* and comprises about 200 species. It is found all over the tropics and subtropics. Many *Cissus* species have uses in traditional medicine in Asia, South America, the Caribbean and in tropical Africa.

Ecology *Cissus dinklagei* is a species of dense evergreen forest.

Genetic resources and breeding In view of its wide distribution, genetic erosion of *Cissus dinklagei* is not likely.

Prospects Several pharmacological effects of *Cissus* species, e.g. antispasmodic and anti-inflammatory, may be of interest for future developments. Research will be needed to fully evaluate the potential of *Cissus dinklagei*.

Major references Descoings, B., 1972; Dewit, J. & Willems, L., 1960; Raponda-Walker, A. & Sillans, R., 1961.

Other references Aguilar, N.O., 2001b.

Authors C.H. Bosch

CISSUS PALMATIFIDA (Baker) Planch.

Protologue DC., Monogr. phan. 5(2): 473 (1887).

Family Vitaceae

Origin and geographic distribution *Cissus palmatifida* has been recorded from Senegal, Mali, Burkina Faso, Benin, Nigeria, Cameroon, Central African Republic and Sudan.

Uses The leaves of *Cissus palmatifida* are used in the preparation of sauces. The ripe fruit has edible pulp.

Properties No information is available on the chemical composition of *Cissus palmati-*

fida. Several other *Cissus* species, used in traditional medicine in South Africa, South America and Asia, have been the subject of investigation, and a wide range of compounds have been identified; several of these compounds showed anti-inflammatory, antispasmodic and antitumour activities.

Botany Perennial herb trailing or climbing with few leaf-opposed, simple tendrils; stem glabrescent. Leaves alternate, digitately 3–5-lobed; petiole 2.5–5 cm long; blade c. 11 cm long, base truncate to slightly cordate, lobes deeply lobulate. Inflorescence a cyme with umbel-like, 6–12-flowered clusters. Flowers bisexual, 4-merous, yellow; calyx cup-shaped, 1 mm long, entire; petals c. 1 mm long; ovary superior, subglobose, style subulate. Fruit a subglobose berry 4–5 mm in diameter, black, 1-seeded.

The genus *Cissus* is closely related to *Cyphostemma* and comprises about 200 species. It is found all over the tropics and subtropics. Many *Cissus* species have uses in traditional medicine in Asia, South America, the Caribbean and in tropical Africa.

Ecology *Cissus palmatifida* occurs in savanna woodland.

Genetic resources and breeding *Cissus palmatifida* is fairly widespread and is not liable to genetic erosion. No germplasm collections are maintained.

Prospects *Cissus palmatifida* will probably remain a food plant of local importance. Several pharmacological effects of *Cissus* species, e.g. antispasmodic and anti-inflammatory, are of interest. However, as no medicinal uses are recorded for *Cissus palmatifida*, it is unlikely to figure as a priority species for research.

Major references Baker, J.G., 1868; Burkill, H.M., 2000; Keay, R.W.J., 1958a.

Other references Aguilar, N.O., 2001b.

Authors C.H. Bosch

CISSUS PRODUCTA Afzel.

Protologue Rem. Guin. 9: 63 (1815).

Family Vitaceae

Vernacular names Oseille des Pygmées (Fr).

Origin and geographic distribution *Cissus producta* occurs from Senegal east to Uganda and south to Angola, Zambia and Zimbabwe.

Uses The leaves of *Cissus producta* are eaten in Gabon as a vegetable. The taste is very acid, not unlike that of sorrel (*Rumex*). The stems yield potable water when cut.

In Sierra Leone ripe fruits are rubbed on the forehead or are crushed and tied around the forehead to treat headache. In DR Congo *Cissus producta* is considered a cure for gonorrhoea. In Sudan an emulsion of the roots is used to protect cows from bites of tsetse flies. The emulsion is applied by rubbing on the skin or by internal dosing. In Tanzania roots are pounded with water and sprinkled on tumours of cows to cure them. Magical powers are attributed to *Cissus producta* in Senegal, Nigeria and Gabon.

Properties No information is available on the chemical composition of *Cissus producta*. Several other *Cissus* species, used in traditional medicine in South Africa, South America and Asia, have been the subject of investigation, and a wide range of compounds have been identified; several of these compounds showed anti-inflammatory, antispasmodic and antitumour activities.

Botany Perennial climbing herb or liana with leaf-opposed, simple tendrils; young stem cylindrical, fleshy, older stem 4-angled, up to 15 m long. Leaves alternate, simple; stipules ovate-triangular, early caducous, 2–3.5 mm long; petiole 1–8 cm long; blade oblong-triangular, oblong-ovate or broadly lanceolate, up to 14 cm × 9 cm, base truncate to subcordate, apex acuminate. Inflorescence an axillary or terminal cyme with umbel-like clusters 3–5(–10) cm long. Flowers bisexual, 4-merous; calyx cup-shaped, 1 mm × 2.5 mm, entire; petals narrowly triangular, c. 3 mm long, pink or yellowish; ovary superior, glabrous. Fruit an ovoid to ellipsoid berry up to 18 mm × 10 mm, purplish-red to black, 1-seeded. Seed compressed (oblong-)subglobose, very slightly reniform, up to 13 mm long.

The genus *Cissus* is closely related to *Cyphostemma* and comprises about 200 species. It is found all over the tropics and subtropics. Many *Cissus* species have uses in traditional medicine in Asia, South America, the Caribbean and in tropical Africa.

Ecology *Cissus producta* occurs in evergreen forest, gallery forest and periodically inundated forest at altitudes up to 1050 m.

Genetic resources and breeding *Cissus producta* is widespread and as such a risk of genetic erosion is not envisaged.

Prospects Several pharmacological effects of *Cissus* species, e.g. as antispasmodic and anti-inflammatory, may be of interest for future developments. Research will be needed to

evaluate the full potential of *Cissus producta*.

Major references Baerts, M. & Lehmann, J., 2002b; Burkill, H.M., 2000; Raponda-Walker, A. & Sillans, R., 1961; Verdcourt, B., 1993.

Other references Aguilar, N.O., 2001b.

Authors C.H. Bosch

CITRULLUS LANATUS (Thunb.) Matsum. & Nakai

Protologue Cat. Sem. Spor. Hort. Bot. Univ. Imp. Tokyo 30: No 854 (1916).

Family Cucurbitaceae

Chromosome number $2n = 22$

Synonyms *Momordica lanata* Thunb. (1794), *Citrullus vulgaris* Schrad. ex Eckl. & Zeyh. (1836), *Colocynthis citrullus* (L.) Kuntze (1891).

Vernacular names
- Egusi melon, egusi watermelon, West African watermelon (En). Pastèque égousi, melon à pistache (Fr).
- Watermelon, dessert watermelon (En). Pastèque (Fr). Melancia (Po). Mtikiti, mtikiti maji (Sw).
- Cooking melon, fodder melon, preserving melon, citron (En). Pastèque à cuire, pastèque fourragère, citre, méréville (Fr).

Origin and geographic distribution *Citrullus lanatus* originates from the western Kalahari region of Namibia and Botswana, where it can still be found in the wild in a diversity of forms together with other *Citrullus* species. In this region there are two major types, one with small fruits that are generally bitter and mainly used for their seeds, called 'tsama melon'. This is the probable ancestor of egusi melon. The other type has fruits that are mainly used as a source of water during periods of drought or as cooking melons, and may well represent the ancestral form of the watermelon, fodder melon and cooking melon. Following first domestication of *Citrullus lanatus* in southern Africa in prehistoric times, its cultivation became widespread in Mediterranean Africa, the Middle East and West Asia more than 3000 years ago. Introduction into India must also have occurred in ancient times and here a strong secondary centre of genetic diversity developed. *Citrullus lanatus* reached China around the 10th century and Japan in the 16th century. It was introduced to the Americas in early post-Columbian times.

Egusi melon, grown for its seed, has probably been domesticated in the southern Sahel zone or in regions surrounding the Kalahari desert. It is especially important in West Africa. People in Namibia and Botswana still harvest most of their seeds from the wild, but some landraces have been selected specifically for their oil-rich seed. Cultivars grown in western Sudan are probably of the same type as the egusi melon of West Africa. Seed melons are also important in China.

Citrullus lanatus – wild and planted

Watermelon is now widespread in all tropical, subtropical and warm temperate (hot summers) regions of the world, including Africa. Cooking melons are mainly found in the northern and eastern parts of the Kalahari desert. Fodder melon is mainly grown in the United States and South Africa.

Uses *Citrullus lanatus* comprises overlapping groups of cultivars that yield seed or edible fruits. Fruits of wild or semi-wild plants are used in the Kalahari region as a source of drinking water. The same use is reported from Sudan. Other primitive forms are used as forage.

Most important in Africa are cultivars of which the only edible portion are the seeds. The fruit pulp of these cultivars is too bitter for human consumption. In West Africa they are called 'egusi', derived from the Yoruba language; in Wolof language (Senegal) they are called 'beref'. In the Kalahari region, the seeds are considered a delicacy. After roasting, they are ground into a coarse, whitish meal, which is nutritious and pleasantly nutty-tasting. In West Africa the seeds are made into pulp and added as thickener to soups. They are also fermented to produce a sweetener locally called

'ogiri' or they are roasted, pounded, wrapped in leaves and then boiled to produce another sweetener called 'igbãlo'. The pulp of roasted and salted seeds is eaten in Sudan and Egypt, where it is called 'tasali'. In the far northern parts of Sudan seeds of some types are eaten whole, including the seedcoat, after being roasted; these are called 'gorom'. A highly prized vegetable oil is extracted from the seed. This oil is used for cooking and for cosmetic purposes and is of interest to the pharmaceutical industry. The residue from oil extraction is made into balls that are fried to produce a local snack called 'robo' in Nigeria, or is used as cattle feed. The oil is used in making soups and in Namibia it has traditionally been used for making soap. The seeds can be roasted to make a substitute for coffee.

Many cultivars are grown as a vegetable crop for fresh consumption of the refreshingly juicy and sweet flesh of the mature fruit. In most parts of the world the watermelon is the most important type of *Citrullus lanatus*.

In several African countries, local non-sweet, non-bitter cultivars are used as cooking melon, e.g. in Kenya, Namibia, Botswana and Zimbabwe. Related types in Sudan are sometimes referred to as 'citron' or 'citronnel'. Young fruits from which the seeds have been removed are cooked until they are soft. In Zimbabwe the cooked melons are mixed with cooked beans or cowpeas, and powdered seeds of bottle gourd are added. To preserve the fruit flesh, the seeds and rind are removed and slices are dried in the sun. A stiff porridge is made from mature fruits mixed with maize or pearl millet flour. The leaves are occasionally used as a cooked vegetable. In the United States the rind of some cultivars is made into pickle or a sweet preserve. In the south of France, the preserving melon or citron is popular for jams. In the extensive farming systems of semi-arid regions, leaves and fruits of fodder melons are a source of forage and water for livestock. The fruits are used as a drastic purgative in Senegal; they are diuretic and used to treat diarrhoea and gonorrhoea in Nigeria. Tar is extracted from the seeds and used for the treatment of scabies and for skin tanning.

Production and international trade West and Central Africa are the largest producers of egusi seed, but statistics are scarce. FAO statistics include melon seed, but they also refer to seed of *Cucumeropsis mannii* Naudin and several *Cucurbita* species. World production of melon seed in 2002 was reported as 576,000 t from 608,000 ha. Production in Nigeria amounted to 347,000 t from 361,000 ha, Cameroon produced 57,000 t, Sudan 46,000 t, DR Congo 40,000 t, Central African Republic 23,000 t and Chad 20,000 t. Outside Africa, China is important with a production of 25,000 t. An estimated 5000–7000 t is traded from Nigeria to other West African countries. Sudan (where production for seed is important especially in Kordofan) exports about 27,000 t, mainly to Arab countries; however, quantities fluctuate strongly from year to year. Unrecorded trade of pulp and oil from the seed to African communities in North America and Europe occurs. For the Kalahari region international trade has recently started, but is still on a small scale.

Annual world production of watermelon increased from 30 million t from 2.1 million ha in 1992 to 81 million t from 3.2 million ha in 2002. China alone produced 57 million t from 1.8 million ha in 2002. Other major producers of watermelon include Turkey with 3.9 million t, North Africa (Algeria, Egypt, Libya, Morocco and Tunisia) 2,9 million t, Commonwealth of Independent States 2.8 million t, Iran 1.9 million t, United States 1.8 million t, Mediterranean Europe (Greece, Italy, Spain) 1.8 million t, Mexico 871,000 t and Brazil 620,000 t. Countries in tropical Africa with sizeable watermelon production are Senegal with 224,000 t, Sudan 143,000 t, Cameroon and Somalia each 28,000 t and Mauritania 11,000 t. Watermelon is mainly produced for local and urban markets, each country having its preferences for size and type. Production for export markets has developed in the Mediterranean region, Mexico, Taiwan, Malaysia and Thailand, with mainly smaller-fruited F_1 hybrid cultivars, including seedless types.

No information is available on the production and trade of cooking melon.

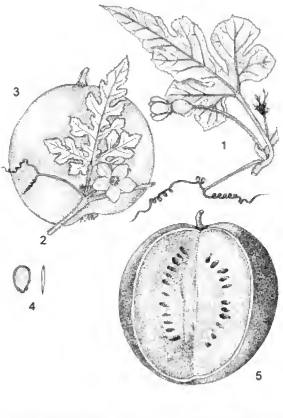
Properties The composition of dried egusi seed without shell per 100 g is: water 5.1 g, energy 2340 kJ (557 kcal), protein 28.3 g, fat 47.4 g, carbohydrate 15.3 g, Ca 54 mg, P 755 mg, Fe 7.3 mg, thiamin 0.19 mg, riboflavin 0.15 mg, niacin 3.55 mg, folate 58 µg. The seed is an excellent source of energy and contains no hydrocyanic acid, making it suitable as livestock feed. The seed oil consists of glycosides of linoleic, oleic, palmitic and stearic acids. The fruit flesh contains bitter cucurbitacins.

The composition of watermelon per 100 g edible portion (50–70% of the mature fruit) is: water 91.5 g, energy 134 kJ (32 kcal), protein

0.6 g, fat 0.4 g, carbohydrate 7.2 g, Ca 8 mg, P 9 mg, Fe 0.17 mg, thiamine 0.08 mg, riboflavin 0.02 mg, niacin 0.2 mg, folate 2 mg, ascorbic acid 9.6 mg (USDA, 2002). The total soluble solids (TSS) content of the fruit flesh, mainly sucrose and fructose and measured by a refractometer (°Brix, equivalent to% TSS), is an important property for quality; 8% is marginal, 10% acceptable and 12% or higher excellent. Watermelon is a rich natural source of lycopene, a carotenoid of great interest because of its antioxidant capacity and potential health benefits.

Adulterations and substitutes Seeds of *Citrullus lanatus* may be replaced by several other cucurbit seeds which are generally referred to as egusi seeds; the most important of these is the real egusi, *Cucumeropsis mannii*.

Description Monoecious, annual, scandent or trailing herb up to 4(–10) m long, climbing by (1–)2(–4)-fid tendrils; roots shallow, with a taproot and many lateral roots; stem ridged, rather softly long-hairy. Leaves simple, alternate; stipules absent; petiole 2–14 cm long, long-hairy; blade oblong-ovate in outline, 4–25 cm × 3–19 cm, deeply palmately 3–5(–7)-lobed,



Citrullus lanatus – 1, part of stem with female flower; 2, part of stem with male flower; 3, egusi melon fruit; 4, seeds of egusi melon; 5, watermelon fruit (rind and flesh partly removed). Redrawn and adapted by Iskak Syamsudin

lobes usually more or less pinnately sinuate-lobulate, margin shallowly sinuate-toothed, long-hairy on the veins, becoming scabrid-punctate. Flowers solitary in leaf axils, unisexual, 2–3.5 cm in diameter, regular, 5-merous, yellow; pedicel 1.5–4 cm long; calyx campanulate; petals united below; male flowers with 3 free stamens; female flowers with inferior, 1-celled, hairy ovary, stigma 3-lobed. Fruit a berry, usually globose to oblong or ellipsoid, sometimes ovoid, 5–70 cm long and weighing 0.1–30 kg (0.1–2.5 kg in egusi melon, 1.5–30 kg in watermelon), white to green, grey or yellow, uniform or mottled or striped, flesh white to pale green, yellow or red, many-seeded. Seeds obovate to elliptical, flattened, 0.5–1.5 cm × 0.5–1 cm, smooth, yellow to brown or black, rarely white. Seedling with epigeal germination; cotyledons leafy, rounded to oblong.

Other botanical information *Citrullus* belongs to the tribe *Benincaseae* of the subfamily *Cucurbitoideae*. It comprises 4 species, 2 of which are endemic to Namibia. All species can be hybridized with relative ease, giving fertile F_1 hybrids, but F_2 progeny of crosses with *Citrullus lanatus* as one of the parents showed a high degree of sterility.

Citrullus lanatus is sometimes divided into 3 subspecies:

- subsp. *lanatus*: including wild plants, the 'tsama melon' and Citroides Group, comprising fodder melon and citron melon;
- subsp. *mucosospermus* Fursa: egusi types from West Africa;
- subsp. *vulgaris* (Schrad.) Fursa: comprising cultivated watermelon types classified in Dessert Group, also including cultivars grouped together under Cordophanus Group, a variable cultivar-group in the Sahara, Sahel and East Africa.

However, there is a complete overlap between the various types of this highly polymorphic species. In Africa, seed melons are by far the most important group. In Nigeria, there are two major seed types, which can be differentiated by the presence or absence of a seed edge. The two types are referred to as 'bara' (with prominent thick seed edge with black or white colour) and 'crewe' (without pronounced seed edge). The two seed types can be regarded as different cultivar-groups.

Hundreds of open-pollinated and F_1 hybrid cultivars are available to watermelon growers in the world. 'Charleston Gray' with oblong to cylindrical fruits of 6–15 kg, pale green rind with small veins and pink-red flesh, and 'Sugar

Baby' with globular fruits of 3–8 kg, dark green rind and red flesh are still the most important cultivars in tropical Africa. New F_1 cultivars with improved agronomic characteristics and disease resistance, e.g. 'Logone', 'Sugar Dragon' and the seedless 'Sunshine', are now being introduced to the African market gardeners.

Growth and development Seed will remain viable for at least 8 years when stored dry at temperatures below 18°C. Emergence of the seedling takes 5–7 days. Cotyledons unfold after 10–12 days and the first true leaf appears one week later. In egusi melon lateral branches are produced on the main stem from node 4–6 and the first male flower is formed on node 8–11 at 35–50 days after sowing, the first female flowers on node 15–25 at 45–60 days after sowing. In watermelon both the first male and female flowers are formed somewhat later. The first female flowers often have poorly developed ovaries and fail to set fruit. Flowering peaks 50–80 days after germination. Flowers open shortly after sunrise and remain open only one day. Pollination occurs in the morning and is done by insects, predominantly bees. Ample deposition of pollen on all three stigmas is necessary for regular fruit development. Within 24 hours after pollination the pedicel starts to elongate and bends downward with the swelling ovary. The fruits of watermelon are mature 30–50 days after pollination. At maturity the green fruit stalk turns brown.

Ecology In the wild *Citrullus lanatus* prefers deep sands and occurs especially in dry watercourses and the sandy flats surrounding them. It is also found naturally in disturbed areas or as a weed in cultivated land. It is daylength neutral. Egusi watermelon is cultivated in tropical lowlands up to 1000 m altitude, watermelon up to 2000 m. Both perform better in the savanna region than in the wet forest zone. West African seed types require an average annual rainfall of at least 700–1000 mm and a daytime temperature of 28–35°C. In the Kalahari region, seed melons usually only get 400–650 mm of rain. Excessive rainfall and high humidity give excessive vegetative growth and promote disease infection, mainly leaf and fruit rot, with consequent low yields. Although irrigated dry season cropping gives higher yields, local farmers prefer to plant seed melons during the rainy season, due to lack of irrigation facilities. Seed yield in the dry savanna zone is 2–3 times higher than in the rainforest zone.

Well-drained sandy loam soil with pH 6–7 is adequate; at lower pH values soilborne diseases (*Fusarium*) may become a serious problem. A waterlogged soil predisposes the crop to attacks of anthracnose disease and fruit rot. A moderately rich soil is required for early and close vegetative cover, which is suitable for control of weeds and erosion.

Propagation and planting There is no seed dormancy, but germination is retarded under high temperature regimes. Germination can be accelerated by pre-soaking in water for 24 hours after scarifying the seed at one end, especially for cultivars which have a hard seed coat. Seed germinates best at temperatures of 17°C at night and 32°C at daytime and also at a constant temperature of 22°C. It will not germinate at temperatures below 15°C. Light has an inhibitory effect.

After soil preparation seed melon is sown directly on ridges or in flat plots. Both sole cropping and mixed cropping with maize, pearl millet, sorghum or cowpeas occur. Per hill 3–4 seeds are sown at a depth of 3–4 cm; 3–4 weeks after sowing, at the 2–4 leaf stage, seedlings are thinned to 1–2 per hill. A spacing of 2 m × 2 m or 1 m × 4 m with a population of about 2500 plants/ha is suitable in sole cropping, but a spacing of 2 m × 1 m is also used. The minimum seed requirement for sole cropping is 0.8–1.5 kg/ha; in mixed cropping farmers use 1.0–2.0 kg/ha.

Watermelon is seeded directly in a similar way or transplanted after raising seedlings in pots of 9 cm diameter. Seedlings are transplanted to the field when they have 3–4 true leaves, some 5 weeks after sowing. Planting distances are 0.9–1.2 m × 1.2–1.8 m giving a density of 5000–9000 plants/ha. Seed rates per ha are 1–2 kg for direct-seeded and 0.3–0.5 kg for transplanted watermelon. Seedless (triploid) cultivars are practically male sterile and require a diploid cultivar planted every third row for adequate pollination and fruit set. Fruits of the diploid pollinator cultivar should be clearly distinct for easy separation of the more valuable seedless fruits.

Management A wide crop rotation (cucurbits once in 4–6 years) is essential to avoid damage by soilborne diseases and pests. Supplementary irrigation is required before ploughing in case of prolonged drought. Two or three weedings are needed before the stems grow into a thick vegetative cover over the soil surface, attained in 6–8 weeks after sowing. The movement in the crop should then be reduced to prevent plant damage. *Citrullus lana-*

tus responds well to fertilizers, especially to organic matter. The amount required depends on the nutrient status of the soil. In general application at a rate of 20–30 t/ha organic manure, 50–60 kg N, 10–15 kg P and 20–30 kg K per ha is suitable for good performance. In commercial production of watermelon mulching with polythene sheets (black, transparent or silver-painted) or straw is common practice to conserve moisture, raise or lower soil temperatures, suppress weeds and prevent direct contact of the fruits with the soil. Stems are trimmed to prevent excessively dense vegetative growth and usually only 2 fruits per plant are left to mature, or up to 6 in small-fruited cultivars.

Diseases and pests There are a number of important diseases, although *Citrullus lanatus* is less susceptible than cucumber and melon. Fusarium wilt (*Fusarium oxysporum* f.sp. *niveum*) can be prevented by wide crop rotation (preferably once in 6 years), ensuring good drainage and using tolerant/resistant cultivars. Anthracnose (*Glomerella cingulata* var. *orbiculare*, synonym: *Colletotrichum lagenarium*) can be controlled by dithiocarbamates and organic fungicides, but cultivars resistant to some of the 5 known races are available. Gummy stem blight (*Didymella bryoniae*, synonym: *Mycosphaerella citrullina*) can also be controlled with fungicides, and sources of resistance have been identified in wild *Citrullus* accessions. Powdery mildew (*Sphaerotheca fuliginea*) may occur, but in hot and humid climates downy mildew (*Pseudoperonospora cubensis*) is more important. Bacterial rind necrosis (*Erwinia carnegieana*) may be serious, but differences in susceptibility exist amongst accessions. Bacterial fruit blotch (*Acidovorax avenae* subsp. *citrulli*) is a relatively new disease, reported in China and the United States since 1989, which requires disease-free seeds and seedlings, crop rotation and preventive copper sprays to avoid serious outbreaks. Major virus diseases are watermelon mosaic virus (WMV-2), papaya ringspot virus (PRSV-W) and zucchini yellow mosaic virus (ZYMV), which are all transmitted by aphids and cucumber beetles. Some egusi melon lines are resistant to WMV-2. Other diseases include damping-off and root rot (*Pythium* spp.), Alternaria leaf blight (*Alternaria cucumerina*), Cercospora leaf spot (*Cercospora citrullina*), Phytophthora root, crown and fruit rot (*Phytophthora capsici*), southern blight (*Sclerotium rolfsii*) and squash lead curl virus (SqLCV) transmitted by silverleaf whitefly (*Bemisia argentifolia*).

Root-knot nematodes (*Meloidogyne* spp.), particularly serious on sandy soils, can be prevented by crop rotation, destruction of susceptible weed hosts, solar sterilization of the soil (instead of expensive and environmentally hazardous fumigation) and grafting on resistant rootstocks.

Common insect pests are thrips (*Thrips* spp.), mites (*Tetranychus* spp.), aphids (*Aphis gossypii*), fruit fly (*Dacus ciliatus*), cucumber beetles (*Diabrotica* spp.), red pumpkin beetle (*Aulacophora* spp.), loopers (e.g. *Spodoptera exigua*, *Trichoplusia ni*), *Epilachna* beetles and leaf miner (*Liriomyza* spp.). There are many types of insecticides to control the various insect pests, but indiscriminate spraying usually aggravates the situation by destroying useful parasites. Polythene mulch, especially when coated with reflective aluminium paint, repels thrips and aphids. In southern Africa, the most serious pest is the cucurbit bug *Coridius viduatus*. However, in many cases farmers are not worried about this pest since their larvae form part of the local cuisine.

Harvesting In egusi melon fruit maturity is best determined by the withering of the fruit stalk and ancillary tendril. Fruits are cracked using strong short wooden poles. They are then heaped and covered with dry grass to ferment. Fermentation takes about 14 days. The seeds are then scooped out from the pulp and washed. They are spread out in the open to dry under the sun, and turned over several times to ensure an even drying. Depending on temperatures and cloud cover, the seeds are dry in 5–7 days.

For most watermelon cultivars under tropical conditions the first fruits are ready for harvesting 65–90 days after transplanting to the field. Indications of maturity are a muffled sound when tapping the fruit, the pale spot where the fruit rests on the ground turning yellow, the fruit skin increasing in lustre and losing hairs, and the tendrils directly opposite the fruit stalk turning yellow and shrivelling. Watermelon fruits show non-climacteric respiratory behaviour and therefore do not ripen further after harvest. The fruit is cut with about 5 cm of stalk. Fruits harvested in the afternoon are less turgid and less likely to crack during handling and transport.

Yield In West Africa egusi seed yields vary from 225 kg/ha in Senegal to 1100 kg/ha in Nigeria. In Namibia the seed yield ranges from 550 kg/ha to over 3000 kg/ha, depending on the

cultivar used. In China an average seed yield of 1500 kg/ha has been reported.
Worldwide the yield of watermelon averages about 25 t/ha, varying from 5–60 t/ha, depending on cultivar and cultural practices. Seed yields of watermelon are 150–400 kg/ha for most cultivars. Experimental yields of cooking melon in Namibia are very high and have exceeded 100 t/ha.

Handling after harvest In Nigeria the harvested seeds are bulked and packed in jute bags or bath cloth (20–25 kg) for proper aeration and further drying. Plant parts and sand or stones are removed from the seed lots. The seeds are marketed whole (with the seed coat) or as kernels (without seed coat). A portion of the seeds (in Nigeria 10–20%) is made into pulp for sale in the market. 'Ogiri' is made by alkaline fermentation with *Bacillus* and *Alcaligenes* species. The best temperature for fermentation is 30–35°C.
Watermelon fruits are rather fragile and susceptible to breakage and bruising and should be handled and shipped with care. They can be stored for 2–3 weeks at 10–15°C and 85% relative humidity. In Africa fruits are often greatly damaged as a result of poor handling and transportation.

Genetic resources In Africa most farmers plant and carefully maintain their own local cultivars. Germplasm collections of *Citrullus lanatus* (mainly watermelon) are maintained at universities, horticultural institutes and genebanks in the major producing countries. There is a need to complement existing collections with additional germplasm of *Citrullus lanatus*, related *Citrullus* species and *Acanthosicyos naudinianus* (Sond.) C.Jeffrey from the primary (central and southern Africa) and secondary (India, China) centres of genetic diversity. Egusi watermelon germplasm has been collected and maintained ex situ, e.g. by the Horticultural Research Institute (NHR) and Universities in Nigeria and the Plant Genetic Resources Unit of the Agricultural Research Corporation in Sudan. The diversity of watermelon found in Namibia is represented by seed collections held at Namibia's National Plant Genetic Resources Centre in Windhoek. Improved cultivars have not yet spread sufficiently well among the farmers to pose serious danger to local genetic resources.

Breeding *Citrullus lanatus* is self-compatible but outcrossing is more common. The potential for selfing allows breeders to create a uniform crop in a relatively short time. Breeding programmes in Nigeria and Sudan aim at egusi cultivars with profuse branching, early soil coverage, high number of fruits per plant, many large seeds per fruit, seeds with white colour for export quality and disease tolerance or resistance. In Namibia and Botswana, additional attention is given to the oil content and oil quality of the seeds. Three standard cultivars and nine other promising lines of egusi melon are available at the National Horticultural Research Institute in Nigeria. These are vegetatively very similar but differ in fruit colour, seed type and yield.
Emphasis in breeding watermelon has shifted from developing open-pollinated to F_1 hybrid cultivars. Heterosis effect on yield is not always very large, but other advantages of F_1 hybrids are larger uniformity of plants and fruits, easier manipulation of fruit shape and seed size and effective accumulation of dominant genes for disease resistance in one genotype. For the increasingly popular seedless cultivars F_1 hybrids are the only option. Production of F_1 hybrids in watermelon requires hand-pollination and the seedless hybrids are even more difficult and expensive to produce (only 40–100 seeds per fruit of the tetraploid female line against 200–800 for diploid parents). Seed production of watermelon hybrids is therefore generally carried out in countries with low costs of labour and in arid regions to facilitate the production of high-quality and disease-free seed. The recent discovery of cytoplasmic male sterility in China without linkage to negative plant characteristics offers the opportunity to produce legitimate hybrid seeds by bee-pollination.
Major watermelon breeding programmes are presently carried out by government institutes and private seed companies in Japan, China, Taiwan, India and the United States. The most popular F_1 hybrid cultivars grown worldwide originate from Taiwan, but more recently seed companies in other countries have started breeding specifically for tropical lowland conditions. Main breeding objectives include compact plant types, earliness, small and round fruits, fruits with a thin but strong rind, high sugar content, finely grained flesh with small seeds and no hollow heart, disease and pest resistance (especially Fusarium wilt, anthracnose and viruses), heat tolerance and improved seed production. There are hundreds of open-pollinated and F_1 hybrid cultivars.

Prospects *Citrullus lanatus* seeds are increasingly used for their oil in semi-arid re-

gions and also the use of the oil in the cosmetic and pharmaceutical industry is increasing. There are also prospects for use of the seeds in the improvement of infant nutrition in view of their high protein and fat content. The introduction of new egusi melon cultivars into traditional cropping systems combined with appropriate cultural practices will improve the suppression of weeds and soil erosion and will reduce the production costs. The large diversity of germplasm offers scope for the development of new cultivars. Future research priorities should emphasize high yields through development of vigorous cultivars with early soil coverage and good disease and pest resistance. Further research is needed on the development of improved agronomic practices and labour-saving equipment for seed extraction and shelling. Appropriate storage and oil extraction devices need to be developed whereby oxidation of the oil is minimized.

The demand for watermelon, especially the smaller, ovoid to globular and seedless fruit types, is rapidly increasing in many countries. Sources of resistance to the most important diseases and pests have been identified. Molecular marker-assisted selection and genetic transformation will further increase breeding efficiency in watermelon and may realize effective resistance to diseases and pests, unattainable by conventional breeding. The longer-term prospects of reducing dependence on pesticides when producing watermelon fruits are therefore good. The costs of hybrid seeds are likely to come down once effective male sterility has been incorporated into the female lines of F_1 hybrid cultivars.

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Sources of illustration Stevels, J.M.C., 1990; Vaughan, J.G. & Geissler, C.A., 1997.

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CLEOME GYNANDRA L.

Protologue Sp. pl. 2: 671 (1753).

Family Capparaceae (APG: Brassicaceae)

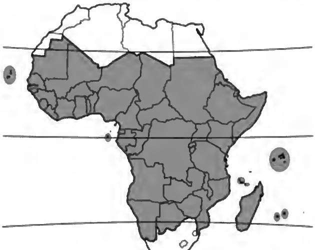
Chromosome number $2n = 30, 32, 34, 36$

Synonyms *Cleome pentaphylla* L. (1763), *Gynandropsis pentaphylla* (L.) DC. (1824), *Gynandropsis gynandra* (L.) Briq. (1914).

Vernacular names Spiderplant, cat's whiskers, spider flower, bastard mustard (En). Caya blanc, brède caya, mouzambé (Fr). Musambe (Po). Mgagani, mkabili, mkabilishemsi, mwangani mgange (Sw).

Origin and geographic distribution The origin of *Cleome gynandra* is not known. There are claims that it has a southern Asian origin, but others suggest that it originates from Africa or Central America. *Cleome gynandra* occurs throughout the tropics and subtropics. In Africa, it is mainly found near human settlements, possibly escapes from earlier introductions. It occurs probably in all countries of tropical Africa.

Uses The tender leaves, young shoots and occasionally flowers are eaten boiled as potherb, relish, stew or side dish. The leaves are utilized in fresh form or dried as powder. Sometimes the leaves are bitter and then cooked with milk and/or with other leafy vegetables such as cowpea leaves, amaranth, nightshades (*Solanum* spp.) and *Cleome mono-*



Cleome gynandra – wild and planted

phylla L. In other areas the leaves are boiled and the cooking water is discarded. In several countries, pounded groundnut paste (peanut butter) is added to improve the flavour. The leaves may be blanched, made into small balls and sun- or air-dried. This is a popular product in southern Africa, which finds a ready market when available during the rainy season. These balls or leaf powder can be stored up to a year and are soaked in water before being used in cooking. The seeds may be used as a substitute for mustard.

In several communities, boiled spiderplant leaves are traditionally given to mothers before and after delivery of a child, and in other situations where blood has been lost, e.g. to warriors. Similarly, an infusion of the leaves is used to treat anaemia. The leaves and seeds are used medicinally as rubefacient and vesicant, and to treat rheumatism, externally as well as internally. An infusion of the roots is used as a medicine for chest pain, the leaves to treat diarrhoea. Spiderplant seeds thrown in water can kill fish, which then float to the surface. The glands on the stems and leaves have insect repellent properties; cabbage and related crops intercropped with spiderplant suffer less from diamond back moth larvae. Similarly, in French bean intercropped with spiderplant, the beans are less affected by flower thrips and are therefore of better quality for export.

The seeds are used to feed birds. The seed contains an edible polyunsaturated oil, which is extracted by simple pressing and does not need refining. The seed cake can be used as animal food.

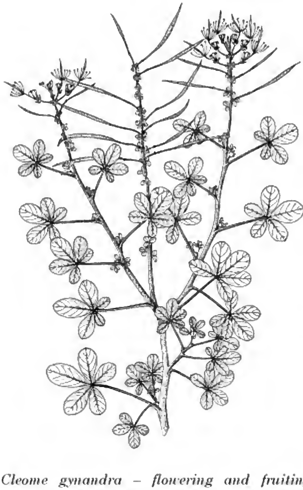
Production and international trade Especially in East and southern Africa, spiderplant is sold in rural and in urban markets during the rainy season. So far only limited quantities are produced under irrigation but there are signs in a number of countries that this is about to change, now that seed of improved cultivars is commercially available. In urban centres, it is becoming increasingly popular with demand frequently surpassing supply. Some limited cross-border trade takes place of the dried produce, e.g. from Zimbabwe to Botswana. No statistical data are available.

Properties The composition of *Cleome gynandra* per 100 g edible portion is: water 86.6 g (83.3–89.6), energy 142 kJ (34 kcal), protein 4.8 g, fat 0.4 g, carbohydrate 5.2 g, fibre 1.2 g, Ca 288 mg, P 111 mg, Fe 6.0 mg, ascorbic acid 13 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968).

The seeds contain the glucosinolates cleomin and glucocapparin, and an acrid volatile oil comparable with mustard oil. The essential oil is also present in the leaves, and is responsible for the odour and flavour of the vegetable. In Kenya *Cleome gynandra* was shown to exhibit repellent and acaricidal properties to larvae, nymphs and adults of the ticks *Rhipicephalus appendiculatus* and *Amblyomma variegatum*, indicating a potential for tick control. Carvacrol was one of the most repellent compounds of the essential oil.

There are also reports of anti-HIV and antibacterial activities of spiderplant, and of inhibition of the growth of the mosquito *Culex quinquefasciatus*. The presence of glucosinolates, which have irritant properties in contact with the skin, explains the use of spiderplant as an antirheumatic and counter-irritant in traditional medicine.

Description Erect annual herb up to 150 cm tall, strongly branched, with long taproot and few secondary roots; stem densely glandular. Leaves alternate, palmately compound with (3–)5(–7) leaflets; stipules absent; petiole 2–10



Cleome gynandra – flowering and fruiting shoot.
Source: PROSEA

cm long, glandular; leaflets almost sessile, obovate to elliptical or lanceolate, 2–10 cm × 1–4 cm, cuneate at base, rounded to obtuse, acute or acuminate at apex, margins finely toothed, sparsely to distinctly hairy. Inflorescence a terminal raceme up to 30 cm long, bracteate. Flowers bisexual, white or tinged with purple; pedicel 1.5–2.5 cm long; sepals 4, free, ovate to lanceolate, up to 8 mm long; petals 4, elliptical to obovate, up to 1.5 cm long, clawed; androgynophore 1–1.5 cm long; stamens 6, purple; ovary superior, stalked, 2-celled. Fruit a long, narrow, cylindrical capsule up to 12 cm × 1 cm, stalked and beaked, usually green or yellow, dehiscing from below with 2 valves, many-seeded. Seeds subglobose, 1–1.5 mm in diameter, grey to black, irregularly ribbed. Seedling with oblong cotyledons; first leaves 3-foliolate.

Other botanical information *Cleome* comprises 150–200 species, about 50 of them occurring in Africa. It is classified in the subfamily *Cleomoideae*, sometimes considered as a separate family *Cleomaceae*. *Gynandropsis* has been merged with *Cleome*, as the distinguishing character, i.e. the connection of the staminal base with the gynophore to form an androgynophore, is merely a quantitative character. The spiderplant has a distinct androgynophore with stamens and ovary well beyond the corolla, whereas the other African *Cleome* species used as vegetable do not have such an androgynophore.

Growth and development After sowing the first seedlings emerge after 6–8 days. However, germination is erratic, occurring over an extended period. Dormancy is much reduced some 6 months after the seeds have dried, and after 12 months most seeds germinate readily. Initial seedling growth is slow, especially when night temperatures are low. A deep root system is apparently formed first, later followed by foliage development. The highest growth rate occurs 5–6 weeks after germination. The leaves display strong circadian movements, which follow the direction of the sun. These movements are stronger at high light intensity and temperature. Like amaranths, spiderplant has a C_4 cycle showing highly efficient photosynthesis under favourable conditions of temperature, soil moisture and light. Apical dominance is usually weak, as auxiliary buds start breaking between the second and third week of plant growth but there is considerable variation in this character with some plants having few branches only. Plants tend to start flowering 4–6 weeks after germination, usually when 60–90 cm tall; stress can trigger flowering even at the seedling stages. Regular picking and deflowering encourages lateral growth thus extending the harvesting period, which will be helped further by top dressing with a nitrogenous fertilizer and adequate moisture supply. After repeated harvesting the remaining plant will flower for an extended period until the rains stop. During the reproductive stage, which may take up to three months under favourable conditions, vegetative growth declines and leaves become senescent quickly. The fruits dry after a few weeks and dehisce to release dry seeds.

Cleome gynandra is both self- and cross-pollinated. In Venezuela plant populations with either male or female flowers were found. Such populations have not been recorded in Africa. In studies carried out in Zimbabwe in 2001 it was observed that some flowers first develop stamens, others first the pistil. A population has been found with a few plants that show male sterility, producing short anthers that do not shed pollen.

Ecology *Cleome gynandra* occurs from sea level up to 2400 m altitude and requires warm conditions; growth is hampered below 15°C. It is less common in areas with a very humid climate. It tolerates some drought, but water stress hastens maturity and senescence. It is insensitive to daylength. Spiderplant is found on a wide range of soils, mostly on sandy to clayey loam, provided they are deep and well drained with pH 5.5–7.0. It prefers soils with high organic matter and adequate mineral reserves. Spiderplant is a weed in crops on fertile well-manured soils.

Propagation and planting There are approximately 1250 seeds per g. Traditionally new crops of spiderplant are established spontaneously from natural seed dispersal. This system is gradually being replaced by actual farming, whereby the seeds are sown directly in a well-prepared seedbed either on flat land or on ridges or beds. The seeds are very small and therefore mixed with dry sand at a ratio of 1:10. This mixture is either broadcast or drilled in rows spaced at 30–60 cm. Deep sowing should be avoided because it hampers germination. Seedlings emerge after 4–8 days. Thinning is done 3 weeks later to leave 10–20 cm between the plants when sown in lines or 25–30 cm in each direction when broadcast. The thinned plants are usually consumed. Transplanting is only possible at the very early stage because young seedlings have a taproot with few lateral roots. Transplanting at 30 cm is

reported from Côte d'Ivoire. In Zimbabwe, raising seedlings in plastic trays has been investigated with encouraging results.
Some farmers, e.g. in Uganda, sow a mixture of spiderplant with amaranth and one of the nightshade (*Solanum*) species by broadcasting the seeds, and harvest the fastest growing crop first, leaving more space for the others, which will be harvested during the following weeks.

Management Spiderplants do not form a dense leaf cover, so that weeding is needed especially during the first 6 weeks. Experiments in Tanzania and Zambia have shown that the optimum nitrogen rate as sulphate of ammonia or calcium ammonium nitrate is 120–130 kg/ha, but higher recommendations are also given. After thinning at 3–4 weeks, a top dressing of up to 100 kg/ha of ammonium nitrate is recommended. Nitrogen applications delay the onset of flowering and will thus ensure a longer harvesting period. The crop should be sown with the onset of the rains to ensure adequate moisture during the growing season. In areas with limited rainfall like in Botswana and Namibia, farmers may sow in dry land before the first rains. The usually irregular germination ensures that there is enough seed left for later rains when a long interval between the first and successive rains may kill the first seedlings. Water stress reduces the yield and quality and enhances early senescence. Spiderplant can well be produced in the dry season under irrigation. It requires less water than most other conventional vegetables. Flooding is not tolerated.

Diseases and pests The main fungal diseases are powdery mildew (*Sphaerotheca fuliginea*, *Oidiopsis taurica*) and leaf spot (*Cercospora uramensis*). Cabbage aphid (*Brevicoryne brassicae*) is a serious pest causing stunted growth and wrinkling of the leaves and growing tips; it possibly spreads virus diseases. This aphid has recently caused total crop failure in Tanzania. The hurricane bug (*Bagrada* spp.) may similarly affect spiderplant; the attacks are more prevalent during dry periods, but can be effectively controlled with insecticides. Spiderplant can be attacked by many other insects, e.g. pentatomids (*Acrosternum gramineum* and *Agonoselis nubilis*) and flea beetles. It is susceptible to root-knot nematodes (*Meloidogyne* spp.).
Young seeds are eaten by weaver birds. Fruits can also harbour insects that consume the young seeds. American bollworms are frequently found inside the fruits. When a crop is grown for leaves and seed, application of insecticides should be considered from the moment that harvesting of leaves has come to an end.

Harvesting Spiderplant is traditionally picked at the beginning of the rainy season when vegetables are scarce. In cultivation, seedlings are thinned when the plants reach a height of 15 cm, which constitutes the first harvest. When adequate space has been created, the top shoot from the remaining plants will be picked, allowing new side shoots to develop. Some farmers just pick the tender leaves and young shoots whilst others wait for the shoots to grow out and harvest these when they are about 25 cm long. This process of ratoon cropping can be repeated several times. For seed harvesting, the easiest way is to collect fruits before they are fully ripe and to dry them under controlled conditions.

Yield Cumulative leaf yields of 30 t/ha per season may be attained. Weekly leaf yields increase until about the 7th week of growth and then start to decline. By the 10th week of growth, yields have declined by about 90% and the harvest is stopped. The leaf bitterness increases with age as well. A healthy crop in which two or three pickings of shoots have taken place may subsequently yield up to 500 kg of seed per ha.

Handling after harvest Spiderplant leaves are delicate and wilt readily when exposed to the sun. It is important to keep them cool and to sprinkle them with fresh water. People in rural areas preserve part of the crop by sun drying. For this purpose, leaves are allowed to wilt a bit before being blanched and spread to dry. In Botswana and Namibia, fresh leaves are cooked for 2 hours with some salt added to remove the bitter flavour. The boiled leaves are kneaded into small balls, which are then dried in the sun. These balls can be stored until the next rainy season. Soaking the balls in water will reconstitute the leaves, after which they can be prepared for a meal in the same way as fresh produce. In Namibia, the processed leaves are marketed as 'omuvanda' cakes.

Genetic resources Studies in Kenya and Zimbabwe indicate that there is significant variation among plant populations for many characteristics. Further studies are needed to determine to what extent these differences are due to climatic, soil fertility or stress conditions. Clearly different populations can be found in the coastal regions of Kenya and Tanzania, with relatively small plants that are much branched and have distinctly dark, al-

most black, straight and stiff fruits. They appear to be very different from plants encountered elsewhere in Africa, where the fruits are far from stiff and often green or yellow to pale brown. Germplasm collections are maintained in Botswana, Kenya, Namibia, Tanzania, Zambia and Zimbabwe.

Breeding Most farmers use their own local selections. Several seed producers and institutes have made selections from these landraces. The offspring from these selections were found to be rather variable even when self-pollination was applied. AVRDC in Arusha, Tanzania has both a green-stemmed and a purple-stemmed selection and seeds are made available. Similarly, Zambia Seed Company has produced seed for distribution to farmers. In Kenya a cultivar called 'Saget' is sold in seed shops and local selections are sold at rural markets. There is clearly scope for further research here. The focus of genetic improvement is on higher leaf yield, plant uniformity, longer vegetative phase and drought tolerance. The leaf yield is highly influenced by the environment and therefore shows low heritability.

Prospects Spiderplant is a highly appreciated vegetable in many communities in tropical Africa with a good potential for further development. Knowledge of plant breeding and agronomy is still scarce. Also its medicinal properties and use as insect and tick repellent should be investigated further. The seed oil also seems to have potential.

Major references Chayamarit, K., 1993; Chweya, J.A. & Mnzava, N.A., 1997; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Schippers, R.R., 2002a; Windadri, F.I., 2001.

Other references Abbiw, D.K., 1997; Mirghani, K.A. & El Tahir, I.M., 1997; Chigumira Ngwerume, F., 2000; Chigumira Ngwerume, F., Mvere, B. & Mhazo, M., 1998; Chweya, J.A., 1997; Grubben, G., 1967; Kemei, J.K., Wataaru, R.K. & Seme, E.N., 1997; Kwapata, M.B. & Maliro, M.F., 1997; Madisa, M.E. & Tshamekang, M.E., 1997; Malonza, M.M. et al., 1992; Mathenge, L., 1997; Matlhare, T. et al., 1999; Mingochi, D.S. & Luchen, S.W.S., 1997; Mnzava, N.A., 1997; Nkhoma, C.N., Mkamanga, G.Y. & Ruredzo, T.J., 1997; Rubaihayo, E.B., 1997.

Sources of illustration Chayamarit, K., 1993.

Authors N.A. Mnzava & F. Chigumira Ngwerume

CLEOME HIRTA (Klotzsch) Oliv.

Protologue Fl. trop. Afr. 1: 81 (1868).

Family Capparaceae (APG: Brassicaceae)

Vernacular names Spiderplant (En). Musambe (Po). Mgagani (Sw).

Origin and geographic distribution *Cleome hirta* occurs from Ethiopia and Somalia through eastern and central Africa to southern Africa and has occasionally been introduced in western tropical Africa and Madagascar.

Uses In DR Congo, Uganda, Tanzania, Zimbabwe and perhaps elsewhere in its distribution area, Cleome hirta is consumed as a vegetable. The young shoots and leaves are collected, wilted, chopped, boiled, mixed with other vegetables (e.g. peas or amaranth) or used alone when more preferred vegetables are not available, and eaten with a staple food. Sometimes clarified butter ('ghee') is added to improve the palatability. The leaves are taken to reduce hypertension and boiled roots and leaves are used to cure measles.

Properties There is no information on the nutritive composition of *Cleome hirta*, but it is probably comparable to the better known and more widely used *Cleome gynandra* L.

Botany Erect annual or short-lived perennial, sticky herb with a bad smell, up to 180 cm tall; stem striate, sparingly to strongly branched, densely covered with glands. Leaves alternate, digitately 5–9-foliolate; petiole up to 9 cm long; leaflets linear-elliptical, 1–9 cm × 1–5 mm, glandular hairy, decreasing in size upwards. Inflorescence a terminal raceme 10–30(–40) cm long; bracts similar to small leaves but sessile, usually 3–5-foliolate. Flowers bisexual, regular, 4-merous; pedicel up to 1.8 cm long; sepals narrowly lanceolate, 4–12 mm long, glandular pubescent; petals oblong-oblanceolate, up to 2 cm × 4 mm, distinctly clawed at the base for about one third of length, pink to purplish with yellow zone across the middle; stamens usually 10–12, filaments slender, up to 2.5 cm long, subequal, glandular pubescent at base; ovary superior, 1-celled, linear-cylindrical, stalked, glandular pubescent, style 2 mm long, stigma subcapitate. Fruit a cylindrical capsule 6–16 cm × 3–4 mm, stalked up to 2 cm, glandular pubescent, dehiscing with 2 valves. Seeds discoid, 2–2.5 mm in diameter, dark brown, with fine longitudinal striations and pronounced transverse ridges.

Cleome comprises 150–200 species, with the majority in tropical America, whereas about 50

are known from tropical Africa. It is classified in the subfamily *Cleomoideae*, sometimes considered as a separate family *Cleomaceae*. *Cleome allamanii* Chiov. is found in Ethiopia and Kenya, restricted to the surroundings of Lake Turkana on sandy and rocky localities. It resembles *Cleome hirta*, but is a smaller herb. Its leaves are similarly used as a vegetable. In southern Africa, *Cleome maculata* (Sond.) Szyszyl., known from Botswana, Zimbabwe and South Africa, is also eaten as a cooked vegetable. It is also a small herb, up to 30 cm tall, often growing as a weed on disturbed sandy soil.

Ecology *Cleome hirta* occurs in deciduous woodland, dry savanna grassland and on sandy plains. It is also a weed of roadsides, disturbed soils and farmland, from sea-level up to 1800 m altitude. The annual rainfall in the distribution area is usually lower than 700 mm but may be up to 1700 mm.

Management *Cleome hirta* is only collected from the wild, mainly in the early rainy season, and not cultivated. Propagation is possible by seed and cultivation is probably easy, similar to *Cleome gynandra*.

Genetic resources and breeding *Cleome hirta* is widespread and not in danger of genetic erosion.

Prospects *Cleome hirta* will remain a minor vegetable collected from the wild, mostly of importance when other vegetables are scarce. Its nutritional and medicinal properties need investigation.

Major references Codd, L.E. et al., 1970; Elffers, J., Graham, R.A. & Dewolf, G.P., 1964; Katende, A.B., Ssegawa, P. & Birnie, A., 1999; Ruffo, C.K., Birnie, A. & Tengnäs, B., 2002.

Other references Burkill, H.M., 1985; Fici, S., Thulin, M. & Kers, L.E., 1993; Hauman, L. & Wilczek, R., 1951; Kers, L.E., 2000; Maundu, P.M., Ngugi, G.W. & Kabuye, C.H.S., 1999; Oliver, D., 1868; Schippers, R.R., 2000; Wild, H. & Conçalves, M.L., 1973; Wild, H., 1960.

Authors P.C.M. Jansen

CLEOME MONOPHYLLA L.

Protologue Sp. pl. 2: 672 (1753).

Family Capparaceae (APG: Brassicaceae)

Chromosome number $2n = 22$

Vernacular names Spiderplant, spindle pot, bastard mustard (En).

Origin and geographic distribution *Cleome monophylla* is widespread in tropical and subtropical Africa, including Madagascar and other Indian Ocean islands, and is also found in India and Sri Lanka.

Uses Although the fresh *Cleome monophylla* plant has an unpleasant smell and acrid taste, it is locally used as a vegetable in Africa. It is most popular in southern Africa but mainly when better vegetables are not available. Particularly the young leaves and shoots, but sometimes all aboveground parts are used as a cooked vegetable or as a flavouring, alone or mixed with other vegetables and added to a staple food. In Tanzania the seed has been used to prepare a mustard-like vegetable oil.

In Nigeria crushed leaves are rubbed on the head against headache and finely ground leaf is put in the eye to remove irritating particles. In Tanzania dried ground leaves are put on sores, and roots are chewed to treat cough. The whole plant is used externally to treat swellings. In India the leaves and seeds, alone or in a mixture, are applied to ulcers, boils and wounds to prevent the formation of pus. Plant juice, with some water added, is a common remedy against ear inflammations and is a sudorific in cases of fever. The seeds have anthelmintic, rubefacient and vesicant properties.

Properties The nutrient content of *Cleome monophylla* per 100 g (cooked) is: energy 73 kJ (17 kcal), protein 3.0 g, fibre 2.7 g, Ca 1.9 mg, Fe 9.24 mg, Zn 0.43 mg, β-carotene 3.98 mg, folate 50.5 µg, ascorbic acid 13.2 mg (Nesamvuni, C., Steyn, N.P. & Potgieter, 2001). Some people prefer *Cleome monophylla* to *Cleome gynandra* because it is said to be less bitter. In Uganda it is recommended that it be cooked one day before eating to allow slightly toxic enzymes to break down. It is probably because of its smell and taste that cattle will not easily graze it.

An essential oil extracted from *Cleome monophylla* exhibited repellency against the tick *Rhipicephalus appendiculatus* and the maize weevil (*Sitophilus zeamais*), comparable to that of the commercial arthropod repellent diethyltoluamide (Deet). Of the 14 constituents of the oil the major ones are: terpenolene (14%), 1-α-terpeneol (10%), pentacosane (9%), (α and β)-humulene (8%), phytol (5%) and 2-dodecanone (4%). The most repellent components were 1-α-terpeneol and 2-dodecanone.

Botany Erect or spreading annual herb up to 1 m tall; stem densely covered with short glandular and longer non-glandular hairs. Leaves alternate, simple; petiole up to 2.5 cm

long; blade usually lanceolate or oblong, sometimes ovate or linear-lanceolate, 1.5–7 cm × 0.7–3 cm, margin entire, pubescent on both surfaces with hairs like those on the stem. Inflorescence a few-flowered, terminal raceme, in fruit up to 35 cm long. Flowers bisexual, small, 4-merous; pedicel up to 1 cm long; sepals narrowly lanceolate, 3–5 mm long; petals free, obovate to oblanceolate, 3–9 mm × 1.5–2 mm, at base tapering into a thin claw about as long as the sepals, pink to purple; stamens 5–6, two inner ones slightly longer than outer ones, filaments 5–6 mm long; ovary superior, 1-celled, pubescent, style short, stigma capitate. Fruit a spindle-shaped capsule, 3–9 cm × 2–3 mm, with stalk up to 4 mm long, densely covered with glandular and non-glandular hairs, completely dehiscing with 2 valves. Seeds flattened to subglobose, 1.5–2 mm in diameter, dark brown with fine longitudinal striations and low transverse ridges.

Cleome comprises 150–200 species, with the majority in tropical America, whereas about 50 are known from tropical Africa. It is classified in the subfamily *Cleomoideae*, sometimes considered as a separate family *Cleomaceae*. *Cleome monophylla* is easily recognized because of its simple entire leaves.

Ecology *Cleome monophylla* is found in dry savanna grassland, deciduous woodland and bushland, lakeshores, disturbed land and as a weed of cultivation, from sea-level up to 2100 m altitude. In Uganda it grows in areas with an annual rainfall of 700–1200 mm. In dry areas it often grows on humid sandy soil in the rainy season, but it tolerates a wide range of soils.

Management *Cleome monophylla* is collected from the wild and is not cultivated. However, propagation is possible by seed and cultivation methods are similar to those of *Cleome gynandra*, but commercial cultivation does not seem promising because of the small leaves. In Malawi *Cleome monophylla* is a host for the tobacco aphid.

Genetic resources and breeding *Cleome monophylla* is widespread and not in danger of genetic erosion.

Prospects *Cleome monophylla* will remain a minor vegetable of local importance. Its nutritional, medicinal and insecticidal properties deserve more investigation.

Major references Burkill, H.M., 1985; Katende, A.B., Ssegawa, P. & Birnie, A., 1999; Kers, L.E., 1986; Nesamvuni, C., Steyn, N.P. & Potgieter, M.J., 2001; Ruffo, C.K., Birnie, A. & Tengnäs, B., 2002; Schippers, R.R., 2000.

Other references Elffers, J., Graham, R.A. & Dewolf, G.P., 1964; Hauman, L. & Wilczek, R., 1951; Kers, L.E., 2000; Maundu, P.M., Ngugi, G.W. & Kabuye, C.H.S., 1999; Ndungu, M. et al., 1995; Watt, J.M. & Breyer-Brandwijk, M.G., 1962; Wild, H., 1960; Williamson, J., 1955.

Authors P.C.M. Jansen

CLEOME RUTIDOSPERMA DC.

Protologue Prodr. 1: 241 (1824).

Family Capparaceae (APG: Brassicaceae)

Chromosome number $2n = 30$

Synonyms *Cleome ciliata* Schumach. & Thonn. (1827).

Vernacular names Spiderplant, fringed spiderflower (En). Musambe (Po). Mgagani (Sw).

Origin and geographic distribution *Cleome rutidosperma* is a pantropical weed of coastal regions. It is widely distributed from Senegal to Angola, particularly in the coastal regions, but often extending deeply into the interior. Occasionally it has also been found elsewhere in Africa, for example as a weed in East Africa (Uganda, Tanzania). In Nigeria it occurs as a weed in rice fields. In West Africa it is occasionally cultivated as a potherb.

Uses The leaves of *Cleome rutidosperma* are collected from the wild and eaten as a cooked vegetable or added to soup. They have a bitter taste like mustard and in Uganda clarified butter ('ghee') is sometimes added to give it more flavour. It has similar medicinal uses as *Cleome gynandra* L. Leaf sap is applied in Ghana, Gabon and DR Congo to cure earache and deafness. In Ghana a leaf extract is used to treat irritated skin and in Nigeria it is used to treat convulsions. In Malaysia, planting of *Cleome rutidosperma* around field edges may be considered as part of an insect control programme, diverting oviposition of diamondback moth (*Plutella xylostella*) away from cultivated plants. In some areas (e.g. the Philippines, Australia) *Cleome rutidosperma* is a troublesome weed.

Properties Fresh leaves of *Cleome rutidosperma* contain per 100 g edible portion: water 81.0 g, energy 239 kJ (57 kcal), protein 5.5 g, fat 0.9 g, carbohydrate 10.1 g, fibre 1.7 g, Ca 454 mg, Mg 38 mg, P 59 mg, Fe 2.7 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968).

Botany Erect annual herb up to 50 cm tall, branched from the base; stem finely pubescent or glandular pubescent, green-purplish. Leaves alternate, 3-foliolate; petiole up to 7 cm long; leaflets elliptical, 1–6 cm × 0.5–2.5 cm, glabrous to sparsely setulose-pubescent. Inflorescence racemose, lax and not clearly demarcated; bracts similar to leaves. Flowers bisexual, regular, 4-merous; pedicel up to 3.5 cm long in fruit; sepals linear to lanceolate, 2–4.5 mm long, glandular puberulent; petals oblanceolate, 6–11 mm long, usually white, sometimes pinkish; stamens 6; ovary superior, cylindrical, 1-celled. Fruit a cylindrical capsule 3–6 cm × 3–4 mm, with stalk 5–13 mm long, subglabrous, dehiscing with 2 valves. Seeds globular-reniform, c. 2 mm in diameter, orange-brown-black, with fine longitudinal striations and low irregular transverse ridges.

Cleome comprises 150–200 species, with the majority in tropical America, whereas about 50 are known from tropical Africa. It is classified in the subfamily *Cleomoideae*, sometimes considered a separate family *Cleomaceae*. *Cleome rutidosperma* is often confused with *Cleome iberidella* Welw. ex Oliv., which occurs at higher altitudes (1000–1600 m) and is also occasionally used as a cooked vegetable. It has more clearly demarcated racemose inflorescences, its petals are darker coloured and the entire plant is much more pubescent. Both species are also close to a third African species with edible leaves occurring at higher altitudes (1000–2000 m): *Cleome schimperi* Pax. It is possible that these 3 taxa are in fact 1 complex species with different ecological expressions because intermediate specimens have been found.

Ecology *Cleome rutidosperma* grows principally at low altitudes in ruderal, humid, hot conditions. It occurs up to 400 m altitude, in areas with an annual rainfall of 1700–3000 mm. Occasionally it is found as a weed up to 1200 m altitude. Flowering and fruiting plants can be found throughout the year, although most abundantly in the rainy season.

Genetic resources and breeding *Cleome rutidosperma* is widespread and is not in danger of genetic erosion.

Prospects *Cleome rutidosperma* will remain a vegetable of local importance only. Its nutritional and medicinal properties need more research, as does the taxonomy of the complex of which it is part.

Major references Burkill, H.M., 1985; Burkill, H.M., 2000; Elffers, J., Graham, R.A. & Dewolf, G.P., 1964; Katende, A.B., Ssegawa, P. & Birnie, A., 1999; van der Zon, A.P.M. & Grubben, G.J.H., 1976.

Other references Busson, F., 1965; Hauman, L. & Wilczek, R., 1951; Kers, L.E., 1986; Kers, L.E., 2000; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Wild, H. & Gonçalves, M.L., 1973; Wild, H., 1960.

Authors P.C.M. Jansen

CLEOME VISCOSA L.

Protologue Sp. pl. 2: 672 (1753).
Family Capparaceae (APG: Brassicaceae)
Chromosome number $2n = 20$
Synonyms *Cleome icosandra* L. (1753).
Vernacular names Tickweed, wild mustard, spiderplant (En). Cléome visqueuse, cléome gluante (Fr). Musambe (Po). Mgagani (Sw).

Origin and geographic distribution *Cleome viscosa* occurs in northern tropical Africa, from Cape Verde and Senegal to Egypt, Ethiopia and Zanzibar; it is absent in southern Africa, but present in Madagascar and other Indian Ocean islands. Outside Africa it is widespread in peninsular Arabia, tropical Asia, Australia and tropical and subtropical America.

Uses In tropical Africa and elsewhere, *Cleome viscosa* is occasionally used as a leaf vegetable. The bitter leaves are locally popular and eaten fresh, dried or cooked. The pickled young fruits are also eaten. In India the seeds, which have a pleasant flavour, are used as a condiment substitute for mustard seed and cumin in the preparation of pickling spices, sausages, vegetables, curries and pulses.

Cleome viscosa is not grazed by cattle. In areas where it occurs in abundance it can be used as a cover plant and as a green manure (e.g. in Ghana). In Africa and Asia the leaves and seeds are used as a rubefacient and vesicant, and to treat infections, fever, rheumatism and headache. The whole herb is rubbed on the body against rheumatism. Bruised leaves are considered counter-irritant when applied externally to treat herpes infections. Leaf juice mixed with butter is used in the treatment of inflammation of the middle ear and applied on wounds and ulcers. A decoction is used as an expectorant and digestive stimulant (e.g. to cure colic and dysentery) and the vapour from a steaming decoction of the whole plant is inhaled to treat headache. The seeds are carminative but excessive use results in flatulence and distension of the stomach. A decoction of

the seeds is used to treat rheumatism, gonorrhoea, diarrhoea and dysentery, and as a wash to treat piles. The seed and its oil have anthelminthic properties, but they are ineffective in treating roundworm infections. The roots are a remedy for scurvy and rheumatism.

Properties Fresh leaves of *Cleome viscosa* contain per 100 g: water 80.4 g, protein 5.6 g, Ca 880 mg, P 73 mg, Fe 24 mg, ascorbic acid 204 mg (CSIR, 1950). The seed oil (yield 18–37%) contains linoleic acid up to 70%, oleic acid 14%, palmitic acid 10%, stearic acid 5% as well as some volatile components. Rats fed on the oil did not show abnormal growth or reproductive performance or altered liver lipid levels, and it is therefore suggested that the oil might be used safely by humans. A series of coumarino-lignans (cleomiscosins) have been isolated from the seeds. These exhibited antihepatotoxic properties in tests with rats. An aqueous seed extract displayed significant analgesic activity in mice and local anaesthetic activity in guinea pigs. The aerial parts showed antibacterial activity and completely inhibited the growth of *Acromonas hydrophylla* and *Bacillus cereus*. The extracts contain saponins, but alkaloids and tannins are absent. In tests with rats the antipyretic and anti-diarrhoeal activities of the extracts have been confirmed. *Cleome viscosa* seed and shoot extracts have an allelopathic effect on seed germination and growth of pearl millet (*Pennisetum glaucum* (L.) R.Br.).

Botany Annual, erect, branched herb up to 1 m tall, with yellowish, glandular hairs, viscid, with a strong smell when bruised; stem angular-striate, sometimes becoming woody at base. Leaves alternate, digitately compound with 3–5 leaflets; petiole up to 6 cm long; leaflets obovate-lanceolate, 1–5.5 cm × 0.5–2 cm, gradually becoming smaller in higher leaves. Inflorescence a leafy raceme up to 40 cm long in fruit; bracts leaf-like, 3-foliolate. Flowers bisexual, 4-merous; pedicel up to 2 cm long in fruit; sepals lanceolate-oblong, 3–7 mm × 2 mm; petals oblong-obovate, 4–12 mm × 2–3 mm, glabrous, yellow; stamens usually 10–20, filaments c. 7 mm long; ovary superior, cylindrical, sessile, 1-celled, style filiform, short, stigma large, head-like. Fruit a cylindrical, erect capsule 1.5–10 cm × 4 mm, glandular hairy, dehiscing with 2 valves up to the middle. Seeds circular-reniform in outline, up to 1.5 mm in diameter, with strong transverse ribs and fine longitudinal concentric ribs, red-brown, fragrant.

Cleome viscosa – 1, flowering and fruiting branch; 2, flower; 3, fruit; 4, detail of dehiscing fruit; 5, seed.
Source: PROSEA

Cleome comprises 150–200 species, with the majority in tropical America, whereas about 50 are known from tropical Africa. It is classified in the subfamily *Cleomoideae*, sometimes considered a separate family *Cleomaceae*. *Cleome viscosa* is easy to identify with its small yellow flowers, its fruits only opening up to halfway and its sticky indumentum.

The seeds have no dormancy and germinate readily after shedding. Plants start flowering 3–4 weeks after germination and the life cycle is about 3 months. The flowers are ephemeral, opening in the morning and closing in the afternoon.

Ecology *Cleome viscosa* occurs in woodland and grassland, and is a weed of fallow land, fields, roadsides and wasteland, often occurring on sandy soils, but sometimes on calcareous and rocky soils. It is found both under seasonal dry and humid conditions, from sea-level up to 1000 m altitude.

Management *Cleome viscosa* leaves are collected from the wild in Africa. In India the plant is rarely cultivated, but is gaining in popularity as a low-cost substitute for cumin.

Its cultivation is promoted for degraded or marginal agricultural land where it can be cultivated with less difficulty than traditional crops. In pure stands (35,000 plants/ha), seed yields of 600 kg/ha have been obtained. The crop is not attacked by insect pests nor damaged by wildlife because of its sticky nature and strong pungent odour. In-vitro mass propagation for medicinal purposes has been done successfully. In some regions (e.g. United States), *Cleome viscosa* is considered a noxious weed. It is a host for the papaya ringspot potyvirus, which also attacks melons, and for the nematodes *Meloidogyne incognita* and *Meloidogyne javanica*.

Genetic resources and breeding *Cleome viscosa* is widespread and does not seem to be in danger of genetic erosion.

Prospects *Cleome viscosa* will remain a minor leaf vegetable used in times of food scarcity. Its gain in popularity as a seed condiment in India might be interesting for Africa as well. Its nutritional and medicinal properties are promising and deserve more investigation.

Major references Burkill, H.M., 1985; CSIR, 1950; Kers, L.E., 1986; Maikhuri, R.K. et al., 2000; Windadri, F.I., 2001.

Other references Berhaut, J., 1974; Devi, B.P., Boominathan, R. & Mandal, S.C., 2002; Devi, B.P., Boominathan, R. & Mandal, S.C., 2003; Elffers, J., Graham, R.A. & Dewolf, G.P., 1964; Hadj-Moustapha, M., 1965; Kers, L.E., 2000; Parimaladevi, B., Boominathan, R. & Mandal, S.C., 2003; Rukmini, C., 1978; Saxena, B.R., Koli, M.C. & Saxena, R.C., 2000; Singh, P.D.A. & West, M.E., 1991.

Sources of illustration Windadri, F.I., 2001.

Authors P.C.M. Jansen

CNIDOSCOLUS ACONITIFOLIUS (Mill.) I.M.Johnst.

Protologue Contrib. Gray Herb. n.s. 68: 86 (1923).

Family Euphorbiaceae

Synonyms *Jatropha aconitifolia* Mill. (1768), *Jatropha napaeifolia* Desr. ex A.Juss. (1824), *Cnidoscolus napaeifolius* (A.Juss.) Pohl (1827).

Vernacular names Chaya, tree spinach, cabbage star (En). Manioc bâtard (Fr).

Origin and geographic distribution *Cnidoscolus aconitifolius* possibly originated in the Yucatan region of Mexico, but is now widespread in eastern Mexico and Central America. It is also cultivated from northern Mexico to Guatemala and occasionally elsewhere, e.g. in Ghana and Nigeria, where it has been experimentally planted in research stations.

Uses Young chaya leaves and shoots are cooked and eaten, alone or in combination with other vegetables and meat in stews and soups. The leaves are only rarely eaten raw as fresh greens. A popular drink in Yucatan (Mexico) is made by blending raw chaya leaves in sugar water with lemons, pineapple and other fruits and is said to heighten virility. Chaya is also used as forage for domestic animals. Medicinally, chaya has numerous characteristics, ranging from the ability to strengthen fingernails and darken graying hair. It is also used to cure alcoholism, diabetics, insomnia, skin disorders, venereal diseases, gout, scorpion stings and to improve brain function and memory.

Properties Fresh chaya leaves contain per 100 g edible portion: water 72–83 g, protein 4–8 g, fat 0–2.9 g, carbohydrate 6–13 g, fibre 2–3.8 g, Ca 140–500 mg, P 70–100 mg, Fe 2–11 mg, β-carotene 10–18 mg, thiamin 0.2 mg, riboflavin 0.1–0.4 mg, niacin 1.6 mg, ascorbic acid 165–318 mg (Ross-Ibarra & Molina-Cruz, 2002). It also contains HCN 27–42 mg. Uncooked chaya leaves contain cyanogenic glycosides that produce hydrogen cyanide upon tissue damage. The cooking time required to lower HCN to safe levels is about 15 minutes.

Numerous flavonoid compounds have been isolated from chaya and most are kaempferol and quercetin glycosides (e.g. in the cultivated forms: 3-O-rhamnosylgalactoside-7-O-rhamnoside, 3-O-rhamnosylglucoside and 3-O-rhamnoside). Most medicinal properties have never been experimentally tested. Diabetic rabbits, fed increasingly higher quantities of chaya leaves, showed a significant drop in blood sugar levels. Chicks fed diets high in chaya leaf meal had a lower overall mass but a significant increase in absolute heart mass, liver mass, red blood cell count and a significant reduction in mortality. Chaya is known to contain proteolytic enzymes which could explain the use of chaya sap for skin disorders.

Botany Monoecious shrub or small tree up to 6 m tall, containing a white latex, with a thick pale trunk, plants usually armed with stinging hairs, but cultivated forms unarmed. Leaves alternate, simple; petiole 10–30 cm long, glandular at apex; blade very variable, 10–20(–32) cm × up to 30 cm, shallowly or deeply 3–7-lobed, cordate at base, rather thick

and fleshy when fresh, subglabrous and normally without stinging bristles, lobes acute to acuminate. Inflorescence a dichotomous cyme. Flowers unisexual, regular, without petals; sepals 5, up to 1 cm long, petaloid, white; male flowers with 10 united stamens in 2 whorls; female flowers with superior, 3-celled ovary, styles 3, connate at base. Fruit an ovoid-globose, hispid capsule. Seeds 6–8 mm long, carunculate.

Cnidoscolus comprises about 50 species, all American. Most species bear long stiff needle hairs, stinging the flesh much worse than most nettles, the pain often being excruciating and persistent for hours, sometimes accompanied by swelling and blistering. The genus is closely related to *Jatropha* and was combined with it in the past. At present it is considered nearer to *Manihot*. *Cnidoscolus aconitifolius* is divided into 2 subspecies. Subsp. *polyanthus* (Pax & K.Hoffm.) Breckon is restricted to a small area in western Mexico. Subsp. *aconitifolius* is distributed from northern Mexico to Guatemala, and is cultivated up to Peru and occasionally elsewhere. Forms without stinging hairs used as a vegetable are classified as a cultivar-group: Chayamansa Group (synonym: *Cnidoscolus chayamansa* McVaugh). Plants of this cultivar-group produce functionally sterile flowers (very rarely fruits are produced) and are propagated by cuttings; at least 4 cultivars are known: 'Chayamansa' (leaf blade with 5 obovate, strongly overlapping lobes; this is the most common cultivar), 'Estrella' (leaf blade with 5 spreading, not overlapping, dentate lobes), 'Picuda' (leaf blade with 5–9, narrow, strongly dentate to pinnatifid lobes) and 'Redonda' (leaf blade with 3 entire to slightly dentate lobes).

Ecology Under natural conditions in Central America *Cnidoscolus aconitifolius* grows in moist and dry thickets in open forest, often in open rocky localities, from sea-level up to 1300 m altitude.

Management Chaya is propagated by stem cuttings about 40 cm long, that are dried 1–14 days before being planted. It can survive harsh conditions of high temperatures, deep shade, inundations or droughts. It is mostly planted as a hedge in home gardens. Although the plant can reach 6 m in height, the stems are easily broken by wind and it is recommended that a height of less than 2 m be maintained.

Harvesting is best done with protected hands, because even in unarmed plants, long-term contact with the white sap can cause skin irritation. Annual dry leaf yields of up to 12 t/ha are possible on fertile soil with about 9000 plants/ha. The optimum harvest period is only 2–3 months per year, but in home gardens leaves are harvested when needed. Serious diseases and pests are not known.

Genetic resources and breeding *Cnidoscolus aconitifolius* is widespread in Central America and not in danger of genetic erosion.

Prospects Chaya has potential as a home garden crop. With its easy propagation, its tolerance of harsh conditions and absence of serious diseases or pests, it is a promising species worthwhile trying in many locations in tropical Africa.

Major references Kolterman, D.A., Breckon, G.J. & Kowal, R.R., 1984; Ross-Ibarra, J. & Molina-Cruz, A., 2002; Standley, P.C. & Steyermark, J.A., 1949.

Other references Burkill, H.M., 1994; National Academy of Sciences, 1975.

Authors P.C.M. Jansen

COCCINIA ADOENSIS (A.Rich.) Cogn.

Protologue A.DC., Monogr. phan. 3: 538 (1881).

Family Cucurbitaceae

Chromosome number $n = 12$

Vernacular names Wild spinach (En).

Origin and geographic distribution *Coccinia adoensis* is distributed from Ghana eastward up to Ethiopia and southwards to South Africa.

Uses The boiled leaves of *Coccinia adoensis* are eaten in Sudan, Ethiopia, Kenya and Malawi. In Malawi the leaves are mixed with other green vegetables (*Bidens pilosa* L. and pumpkin leaves), tomatoes and groundnuts. The fruits are eaten in Tanzania, Malawi and Zambia. Availability of leaves and fruits is seasonal in Malawi, from August–December and December–January respectively. In Sudan and Malawi the roots are eaten but they are considered a famine food in the latter country. They are poisonous unless well cooked. In Kenya the leaves are crushed, mixed with water and drunk as a cure for puff-adder bites. A root decoction with leaf sap is used as a mouthwash to treat tooth abscesses in Tanzania.

Properties No data are known on the leaf composition, but this is likely comparable to other medium green leaf vegetables. The roots contain per 100 g: water 81 g, energy 289 kJ

(68 kcal), protein 1 g, fat 0.1 g, carbohydrate 16 g, fibre 1 g, Ca 44 mg, Mg 30 mg, P 39 mg, Fe 0.4 mg, thiamin 0.02 mg, riboflavin 0.11 mg, niacin 0.34 mg and ascorbic acid 81 mg.
The fruits contain per 100 g: water 92 g, energy 112 kJ (27 kcal), protein 2 g, fat 2 g, carbohydrate 3 g, Ca 28 mg, Mg 28 mg, P 4 mg, Fe 0.6 mg, ascorbic acid 19 mg (Arnold, T.H., Wells, M.J. & Wehmeyer, A.S., 1985).
The unripe fruits contain cucurbitacin B and traces of cucurbitacin D. Cucurbitacins, which are known from many *Cucurbitaceae* and various other plant species, exhibit cytotoxicity (including antitumour activity), and anti-inflammatory and analgesic activities.

Botany Perennial, dioecious climber or trailer, strigose pubescent on all parts, with simple tendrils; woody rootstock with tubers; stem annual, perhaps rarely perennial, ribbed. Leaves alternate, simple; stipules absent; petiole 0.5–5 cm long; blade variable, ovate in outline, unlobed to shortly or deeply 3–5(–7)-lobed, 3.5–13.5 cm × 2.5–13.5 cm. Male flowers in up to 22-flowered, axillary racemes, peduncle up to 7.5 cm long, with long-pedicellate solitary flower at base of raceme, receptacle obconic, 3.5–7 mm long, corolla pale yellow, pink or orange, with lobes 1–3 cm × 0.5–1.5 cm, united to above the middle; female flowers solitary, receptacle 1.5–3.5 mm long, sepals 1–4.5 mm long, corolla as in male flowers but narrower, ovary inferior. Fruit an ovoid-ellipsoid to ellipsoid-cylindrical berry 3–8 cm × 1–3 cm, smooth, bright red when mature, many-seeded. Seeds broadly ovoid, 6 mm × 3.5 mm × 2.5 mm.
Coccinia is placed in the tribe *Benincaseae* and comprises about 30 species. The genus is confined to tropical Africa, with the exception of *Coccinia grandis* (L.) Voigt (ivy gourd), which extends throughout the paleotropics.
The name *Coccinia quinqueloba* (Sond.) Cogn., belonging to a species restricted to South Africa, has been occasionally misapplied to what appears to be *Coccinia adoensis*.

Ecology *Coccinia adoensis* prefers semi-arid conditions and is absent from the wetter areas of eastern Africa. It occurs in woodland, wooded grassland, grassland and gallery forest up to 2200 m altitude.

Management Leaves, fruits and roots of *Coccinia adoensis* are exclusively collected from wild plants.

Genetic resources and breeding *Coccinia adoensis* is fairly widespread and common throughout its range and therefore not likely to be threatened in the near future. Little is known of the genetic variation within the species. A single accession in a genebank in the United States is documented.

Prospects *Coccinia adoensis* will remain one of the traditional vegetables for people depending on food collection from the wild. Transfer of genes from *Coccinia adoensis* to the economically more important *Coccinia grandis* for breeding is possible.

Major references Arnold, T.H., Wells, M.J. & Wehmeyer, A.S., 1985; Burkill, H.M., 1985; Jeffrey, C., 1978; Jeffrey, C., 1995; Williamson, J., 1955; Zemede Asfaw & Mesfin Tadesse, 2001.

Other references Jeffrey, C., 1995; Keraudren-Aymonin, M., 1975; Meeuse, A.D.J., 1962; Ruffo, C.K., Birnie, A. & Tengnäs, B., 2002; Watt, J.M. & Breyer-Brandwijk, M.G., 1962.

Authors C.H. Bosch

COCCINIA GRANDIS (L.) Voigt

Protologue Hort. suburb. Calcutt.: 59 (1845).

Family Cucurbitaceae

Chromosome number $2n = 24$

Vernacular names Ivy gourd, scarlet-fruited gourd, tindori (En). Tindola, courge écarlate (Fr). Ruho (Sw).

Origin and geographic distribution *Coccinia grandis* occurs wild from Senegal east to Somalia and south to Tanzania; also in Saudi Arabia, Yemen and India. It is locally naturalized in Mozambique and Mauritius and has been introduced in many other tropical and subtropical regions; it is considered an invasive, obnoxious weed in Australia, Florida and

Coccinia grandis – wild

the Pacific Islands, e.g. Hawaii. It is cultivated in Asia from India to Indonesia. In East Africa, especially in Kenya, it is cultivated mainly for consumers of Indian origin.

Uses Ripe red fruit of sweet-tasting cultivars are eaten raw, or they are peeled and cut into pieces and prepared as a stew with onions and tomatoes. Other vegetables may be added such as garden egg, bottle gourd, ridge gourd, okra and pulses. Meat is added when available. The dish may be served with bread, sorghum or any other starchy food. The dish is known in East Africa as 'tindori'. Immature green fruits are prepared in soups and curries and widely used in this way in Ethiopia and India. Cultivars with bitter fruits are mainly used for their leaves and shoots. Such shoots are especially popular in Thailand where they are eaten as a fried or boiled vegetable. The leaves are also eaten as a vegetable by the Mursi people in Ethiopia. The seeds are chewed in Ethiopia and Kenya, but they are discarded in West Africa and Uganda.
The fruits, stems and leaves have medicinal uses such as to reduce high blood pressure and to treat abscesses. Roots are believed to heal illnesses associated with endocrine system disorders such as diabetes mellitus, and are used in Niger to treat intestinal troubles. Bronchial inflammation, respiratory mucosae and skin disorders are also said to be healed by this plant. In some communities in India ivy gourd is cultivated as a medicinal plant. Goats, sheep, cattle, donkeys and camels eat the plant.

Production and international trade In Kenya ivy gourd is produced for the Asian community and also for export. The main production areas are Ukambani and Makuyu. There is a regular export from Kenya to London, but no data on volume are available. In most other countries in Africa ivy gourd fruits and leaves are mainly collected from the wild or occasionally grown in home gardens, e.g. near Kabale in Uganda.

Properties Per 100 g edible portion, the fruits contain: water 93.5 g, energy 75 kJ (18 kcal), protein 1.2 g, fat 0.1 g, carbohydrate 3.1 g, fibre 1.6 g, Ca 40 mg, P 30 mg, Fe 1.4 mg, thiamin 0.07 mg, riboflavin 0.08 mg, niacin 0.7 mg, ascorbic acid 1.4 mg (Rubatzky, V.E. & Yamaguchi, M., 1997). Accurate data on the composition of the leaves are not available.

Description Dioecious perennial herb up to 20(–30) m long, trailing or climbing with simple tendrils, with tuberous rootstock; stem green and longitudinally ribbed when young, becoming white-spotted when older and eventually woody. Leaves alternate, simple; stipules absent; petiole 1–5 cm long; blade broadly ovate to pentagonal or orbicular in outline, 3–12 cm × 3–15 cm, shallowly to deeply palmately 3–5-lobed, cordate at base, margin entire or sinuate and often with distinct reddish glandular teeth, glabrous, punctate. Flowers axillary, unisexual, 5-merous, with tubular receptacle 3–7 mm long, sepals linear, up to 6 mm long, corolla campanulate, with lobes up to 2 cm × 1.5 cm, yellow-orange; male flowers solitary or paired, rarely 3–4 in a short raceme, pedicel 1–7 cm long, stamens 3, united into a column; female flowers solitary, pedicel up to 2.5 cm long, ovary inferior, cylindrical, up to 1.5 cm long, 1-celled, style 3 mm long, stigma 3-lobed. Fruit an ellipsoid or rarely spherical berry 3–7 cm × 1–3.5 cm, fleshy, green with white stripes when young, turning red at maturity, many-seeded. Seeds asymmetrically pear-shaped in outline, compressed, c. 6 mm × 3 mm, margin rather thick and grooved.

Coccinia grandis – flowering and fruiting shoot.
Source: PROSEA

Other botanical information *Coccinia* is placed in the tribe *Benincaseae* and comprises about 30 species, all of them confined to tropical Africa with the exception of *Coccinia grandis*.
Anchote (*Coccinia abyssinica* (Lam.) Cogn.) is cultivated mainly for its tuberous fleshy root-

stock in Ethiopia, but its young shoots are eaten as a cooked vegetable. In Malawi children may eat the fruits of *Coccinia rehmannii* Cogn., although they are said to cause sore eyes; the starchy tuber is eaten after roasting. The leaves of *Coccinia trilobata* (Cogn.) C.Jeffrey are a famine food, occasionally used as a relish by some tribes in Kenya, e.g. in the Mbeere district. The fruits are said to be toxic.

Growth and development Cuttings start developing new leaves and shoots after about one month. Suckers develop after another month, and flowering and fruiting start again one month later. Ivy gourd plants flower profusely and produce many fruits. Flowers only develop on the branches and not on the main stem. Young fruits can already be harvested about one week after flowering. The period from planting to the first harvest takes up to 5 months. Harvesting is best done weekly as long as there is enough moisture to produce new leaves and flowers. The crop could remain in the field for up to 10 years, after which the yields decline and farmers need to establish a new crop. However, replanting after 4 years may be more economical. In the wild, plants can become 20 years or older and the stems may become 30 m long with a diameter of up to 7 cm at the base. Stems become corky with age and both the rootstock and stems act as water reservoirs that enable the plant to survive the dry season.

Ecology Ivy gourd occurs naturally in semi-arid areas, in dry forest or wooded grassland, often in coastal regions, but in Uganda it can be found up to 2000 m altitude and in Ethiopia up to 2350 m. It also occurs in secondary vegetation in highland areas. It grows in a variety of soil types, most frequently on sandy soils.

Propagation and planting Ivy gourd is propagated by means of stem cuttings 10–15 cm long and about 0.5 cm in diameter. Farmers prepare planting holes of 30 cm deep and 60 cm in diameter. Up to 20 kg farmyard manure is added and mixed with soil and water. The cuttings are placed upright or at a slight angle to promote the development of side shoots. When planting is done during a dry spell, farmers should apply enough water and continue watering regularly. Plant spacing is approximately 1 m between plant holes and 1.2–1.6 m between rows. This wide spacing is needed for the long stems, which can reach a length of 10 m or more and require trellising. In home gardens they may be trained over fences or roofs. The wide spacing provides easy access for weeding, pest control and harvesting.
Propagation by seed is little practised because of the dioecious nature of ivy gourd giving 50% non-productive male plants. A ratio of 1 male to 10 female plants is considered adequate for pollination.

Management Ivy gourd may be intercropped with maize or other short-duration crops during its early stages. When the cuttings start growing, irrigation should take place once every 2 days until plants become stronger and irrigation twice weekly becomes adequate. The long stems are trained along a system of vertical and horizontal wires attached to wooden poles.
The first side-dressing is applied about 4–6 weeks after planting when the first new leaves and shoots start to develop. For every plant farmers need to apply up to 500 g of a N-fertilizer, e.g. calcium nitrate. Once the first fruits have been harvested, plants require additional fertilization, e.g. with di-ammonium phosphate, which needs to be applied monthly.
Weeding is done either with a machete or by hand as hoeing might damage the roots. In an established crop irrigation is required from the onset of the dry season to prolong the harvesting season; however, some farmers prefer to give the plants a rest period and wait for the new rains to come. The leaves will dry out during the dry season and need to be removed to make room for new shoots. This is often done by beating the plant, forcing the leaves to drop. Regular pruning is required to stimulate new growth. Older branches dry out and become corky and will no longer produce leaves and flowers. During the dry season when the soil becomes hot, a mulch application is recommended to avoid scorching.
In countries where ivy gourd has been introduced and where no natural predators exist, it can become a serious weed. It grows fast, quickly covering the ground and smothering shrubs and trees in a dense blanket. Control is laborious; uprooting the whole plant is difficult because remaining pieces of the rootstock will regenerate again. This is why landowners in Australia with this plant on their property are obliged by law to destroy it.

Diseases and pests Ivy gourd is host to a range of diseases including powdery mildew (*Sphaerotheca fuliginea, Erysiphe cichoracearum*). Seed-borne anthracnose (*Colletotrichum lagenarium*) may cause heavy losses of fruit especially in storage; it can be controlled by spraying with copper oxychloride. Other dis-

eases include black rot (*Curvularia pallescens*) and stem rot (*Rhizoctonia solani*). Viral diseases, such as watermelon mosaic virus (WMV), may affect the plant. The symptoms include mottling, green blisters, curled leaf margins and distortion of fruit.
A major pest in cultivated crops in Kenya is caused by coreid bugs that feed on new shoots and young fruits. When sucking fruits, they cause distortion of fruits or fruit shedding, whereas a heavy infestation can cause dieback of the shoots. The pumpkin caterpillar (*Diaphania indica*) can be a serious pest on ivy gourd. Aphids (*Myzus persicae*, *Aphis gossypii*) feed on the flowers and affect the development of new fruit. Fruit flies can also be a serious pest. Pesticides should only be applied when needed because they might also kill beneficial insects. Other pests found in Kenya are a weevil (*Acythopeus cocciniae*) and clearwing moth (*Melittia oedipus*) of which the larvae are stem borers that cause the stems to collapse. These two natural enemies are now used as biological control in areas where ivy gourd is a noxious weed.

Harvesting Farmers harvest twice weekly.

Yield Individual plant yields are in the order of 7–10 kg of immature fruits per year; per ha 10–13 t/year may be harvested. Peak production is between the second and fourth year, after which the production declines unless the crop is regularly fertilized, irrigated and pruned. There are no data on yields of leaves.

Handling after harvest The fruits are spread out during the evening in a single or double layer on top of clean sacks. When they are covered or kept inside a sack, they tend to turn yellow outside and pink to reddish inside. Only fresh green fruits which are whitish to pale green inside can be sold. Traders use cold rooms to keep them fresh. When stored in a refrigerator, the fruits last for up to two weeks. Prior to taking the fruits to the market, they are placed in cartons, each containing about 7.5 kg. These cartons are also used for exporting the fruit.

Genetic resources *Coccinia grandis* is only sparsely represented in the germplasm collections of some Indian research institutes. Selection work in India has resulted in several attractive sweet-tasting cultivars. There are no institutes in Africa where germplasm is being maintained. However, a wide diversity exists in the wild throughout its natural range.

Breeding Breeders may look for compact plants with short internodes. Parthenocarpy whereby female flowers develop into a fruit without pollination occurs. It appears that the cultivated crop in East Africa is parthenocarpic, whereas in East Asia male plants are needed for fruit set.

Prospects The demand for ivy gourd from local people is limited and could be met from wild populations, whereas production for the Asian community is likely to remain at the current low level. More research is needed to assess the potential of ivy gourd as a cultivated vegetable for African consumers or as a medicinal plant.

Major references Bates, D.M., Robinson, R.W. & Jeffrey, C., 1990; Boonkerd, T., Na Songkhla, B. & Thephuttee, W., 1993a; Burkill, H.M., 1985; Jeffrey, C., 1967; Katende, A.B., Ssegawa, P. & Birnie, A., 1999; Maundu, P.M., Ngugi, G.W. & Kabuye, C.H.S., 1999; Peter, K.V. et al., 1998; Schippers, R.R., 2002a; SEPASAL, 2003e.

Other references Adam, J.G., Echard, N. & Lescot, M., 1972; Jeffrey, C., 1980; Maggs, G.L., 1998; van Wyk, B.E. & Gericke, N., 2000; Williamson, J., 1955.

Sources of illustration Boonkerd, T., Na Songkhla, B. & Thephuttee, W., 1993a.

Authors Maryam Imbumi

COCCINIA SESSILIFOLIA (Sond.) Cogn.

Protologue A.DC. Monogr. phan. 3: 534 (1881).

Family Cucurbitaceae

Chromosome number $2n = 24$

Synonyms *Cephalandra sessilifolia* Sond. (1862).

Vernacular names Wild cucumber, red gherkin (En).

Origin and geographic distribution *Coccinia sessilifolia* occurs in Botswana, Namibia and South Africa.

Uses The fruit of *Coccinia sessilifolia* is eaten both raw as well as boiled. The ripe fruit tastes sweetish but insipid. The unripe boiled fruit is similar to asparagus in texture and flavour. The root weighs up to 25 kg and is eaten raw, boiled or roasted. It is tasteless and fibrous. Several authors claim that the roots are toxic but at least in the Kalahari desert there are non-toxic plants.

Properties The fruits contain per 100 g: water 82.3 g, energy 256 kJ (61 kcal), protein 2.1 g, fat 0.2 g, carbohydrate 13 g, fibre 1.3 g, Ca 38 mg, Mg 2 mg, P 24 mg, Fe 0.2 mg, thia-

min 0.19 mg, riboflavin 0.13 mg, ascorbic acid 25 mg.
The roots contain per 100 g: water 84 g, energy 197 kJ (47 kcal), protein 1.0 g, fat 0.1 g, carbohydrate 11 g, fibre 2.7 g, Ca 351 mg, Mg 60 mg, P 40 mg, Fe 2.2 mg, thiamin 0.02 mg, riboflavin 0.01 mg, niacin 0.28 mg, ascorbic acid 6.7 mg (Arnold, T.H., Wells, M.J. & Wehmeyer, A.S., 1985). Nutritionally the roots compare favourably with carrot, potato and turnip.

Botany Dioecious, prostrate or scandent herb with deep perennial, fleshy root and annual stems; tendrils simple. Leaves alternate, simple, sessile, amplexicaul; blade ovate, 3–9 cm × 4–13 cm, deeply palmately 3–5-lobed, cordate at base, lobes elliptical to lanceolate. Flowers 5-merous, corolla pale yellow, sometimes tinged pink, lobes 2–3 cm × 1–1.5 cm, united to above middle; male flowers solitary or in small, pedunculate, axillary clusters or racemes with solitary flower at base, receptacle campanulate, 4–5.5 mm long, sepals up to 5 mm long, lanceolate, stamens 3; female flowers solitary, pedicel up to 1.5 cm long, receptacle narrowly campanulate, 3 mm long, sepals 3–4.5 mm long. Fruit an ellipsoid-fusiform or cylindrical berry 5.5–10.5 cm × 2–2.5 cm, bright red when ripe, many-seeded. Seeds asymmetrically ovoid, compressed, 6.5–7 mm × 3–3.5 mm × 1.4 mm.
Coccinia is placed in the tribe *Benincaseae* and comprises about 30 species. The genus is confined to tropical Africa, with the exception of *Coccinia grandis* (L.) Voigt (ivy gourd), which extends throughout the paleotropics.
The fruits of *Coccinia sessilifolia* ripen from December to February and perish fairly rapidly.

Ecology *Coccinia sessilifolia* occurs in dry wooded grassland.

Management Fruits and roots of *Coccinia sessilifolia* are exclusively collected from wild plants.

Genetic resources and breeding *Coccinia sessilifolia* has a limited distribution but seems fairly common within its range and therefore is not likely to be threatened in the near future. Nothing is known about its genetic variation.

Prospects In southern Africa *Coccinia sessilifolia* is considered a good candidate for domestication. Tranfer of genes for breeding of the economically more important species *Coccinia grandis* is possible.

Major references Arnold, T.H., Wells, M.J. & Wehmeyer, A.S., 1985; Jeffrey, C., 1978; Story, R., 1958; van Wyk, B.E. & Gericke, N., 2000.

Other references Watt, J.M. & Breyer-Brandwijk, M.G., 1962.

Authors C.H. Bosch

COLOCASIA ESCULENTA (L.) Schott

Protologue Schott & Endl., Melet. bot.: 18 (1832).

Family Araceae

Chromosome number $2n = 28, 42$

Synonyms *Colocasia antiquorum* Schott (1832).

Vernacular names Taro, dasheen, eddoe, cocoyam, elephant ear (En). Taro, madère (Fr). Colcas, alcolcas, inhame do Egipto (Po). Mjembe, mjimbi, myugwa (Sw).

Origin and geographic distribution *Colocasia esculenta* occurs wild in tropical Asia extending as far east as New Guinea and possibly northern Australia. A type with long stolons occurring throughout this region has been postulated as the ancestor of cultivated taro on the basis of ribosome-DNA analysis. Taro is believed to have been domesticated in northern India, but independent domestication in New Guinea has also been suggested. Domestication is believed to have taken place at a very early date, even before the domestication of rice. It was spread by human settlers eastward to New Guinea and the Pacific over 2000 years ago, where it became one of the most important food plants economically and culturally. Distribution to China and via Arabia to Egypt and East Africa also occurred at least 2000 years ago. From there taro was taken by Arab people to

Colocasia esculenta – planted

West Africa. It was introduced into Europe from Egypt. From Spain it was taken to the New World and new introductions may have been made into West Africa from tropical America. Eddoe types (having a central corm and many large cormels) may have originated in China, from where they spread to the Caribbean region, and from there to Africa. Presently taro is grown in many parts of the tropics and subtropics, as a tuber crop and leafy vegetable. In Africa, the importance of taro as staple food has been eroded by tannia (*Xanthosoma sagittifolium* (L.) Schott) as the latter makes a better fufu. In Africa consumers consider taro as a staple crop of lower value than yam, sweet potato or cassava. In many regions it is naturalized.

Uses The soft white-fleshed corms of taro are eaten boiled, fried or roasted as a side dish or are used for making fufu. They are popular as they quickly satisfy hunger, even when only a small amount is eaten. In cultivars with a single large main corm (dasheen type) the product is comparatively mealy, whereas in eddoe types the cormels have a more firm structure and taste somewhat nutty. The corm is also sliced and fried into taro chips and is used in the preparation of soups, beverages and puddings. It is well tolerated in the diet of allergic children and adults with gastro-intestinal disorders. It is said to reduce dental decay in children. The starch is used in baby foods and as cereal substitute. In Hawaii the corms are processed into flour, used for biscuits and bread; they are also boiled and made into a paste that is left to ferment to produce 'poi'. The Chinese feed peelings and leaves and corms from wild types and inferior cultivars to pigs.

Taro leaves and leaf stalks are used as a leafy vegetable and potherb for soups and sauces, or as relish. They are especially popular in parts of West Africa, north-eastern India and the Caribbean region. The leaves and leaf stalks contain an irritant substance, which causes scratchiness in the mouth and throat, but cooking resolves this. Leaves and leaf stalks of the dasheen type seem to be less acrid than those of the eddoe type. The stolons that are formed in some types are eaten too.

Medicinal uses of taro are few. In Gabon raspings from the corm are applied as a poultice to maturate boils, and to treat snakebites and rheumatism. In Mauritius boiled young leaves are eaten to treat arterial hypertension and liver affections, whereas juice is applied externally to treat eczema. In Madagascar the corms are used to treat boils and ulcers. In Gabon the leaves in combination with leaves of *Tephrosia* sp. are reportedly used in fish poison. Fibre obtained from the leaf stalk has been used for plaiting.

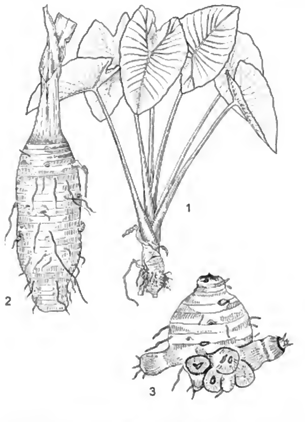
Production and international trade Few sources report the productions of taro and tannia (*Xanthosoma sagittifolium*) separately. World production of taro and tannia corms in 2002 as given by FAO was 9.4 million t from 1.6 million ha; of this amount 7 million t were produced from 1.4 million ha in Africa. Nigeria (3.5 million t) and Ghana (1.8 million t) are the leading producers, followed by China (1.6 million t). An estimate of the annual world production of taro corms indicates about 5.6 million t, with a little more than half of this amount produced in Africa, and 1.6 million t in Nigeria and 0.5 million t in Ghana. Taro corms and leaves, although common in local markets, are mostly grown for subsistence and home consumption. Large-scale commercial production is not common. Local consumption forms the greatest part of taro produced in other continents too. However, small amounts are imported in Europe and Australia for the immigrant community, and also Trinidad and Tobago import some taro.

Properties The nutritional composition of taro corms per 100 g edible portion (66% of product as harvested) is: water 68.3 g, energy 444 kJ (106 kcal), protein 1.4 g, fat 0.2 g, carbohydrate 26.2 g, dietary fibre 3.5 g, Ca 25 mg, Mg 33 mg, P 58 mg, Fe 0.8 mg, carotene 37 μg, thiamin 0.08 mg, riboflavin 0.03 mg, niacin 0.7 mg, ascorbic acid 13 mg. Fresh taro leaves contain per 100 g edible portion (70% of product as harvested): water 85.7 g, energy 147 kJ (35 kcal), protein 4.4 g, fat 0.9 g, carbohydrate 2.6 g, dietary fibre 4.0 g, Ca 110 mg, Mg 45 mg, P 60 mg, Fe 2.3 mg, carotene 6980 μg, thiamin 0.2 mg, riboflavin 0.45 mg, niacin 1.5 mg, folate 39 μg, ascorbic acid 52 mg (Holland, B., Unwin, I.D. & Buss, D.H., 1991).

The itchiness in the mouth and throat that is caused by the fresh uncooked leaves and corm is a result of cells containing raphids (bundles of calcium oxalate crystals) that disappear with cooking. Taro contains enzyme inhibitors, particularly with inhibitory activity against trypsin and chymotrypsin, but these are largely destroyed during cooking. The starch particles are small, 1–6.5 μm in diameter. The corms of some cultivars contain mucilage composed of l-arabinose and d-galactose.

Adulterations and substitutes Leaves and corms of taro can be replaced by leaves and corms of tannia (*Xanthosoma sagittifolium*).

Description Erect perennial herb up to 2 m tall, but mostly grown as an annual; root sytem adventitious, fibrous and shallow; storage stem (corm) massive (up to 4 kg), cylindrical or spherical, up to 30 cm × 15 cm, marked by a number of rings, usually brown, with lateral buds giving rise to cormels, suckers or stolons. Leaves arranged spirally but in a rosette, simple, peltate; petiole up to 1 m long, with distinct sheath; blade cordate, up to 85 cm × 60 cm, with rounded lobes at base, entire, thick, glabrous, with 3 main veins. Inflorescence a spadix tipped by a sterile appendage, surrounded by a spathe and supported by a peduncle much shorter than petiole. Flowers unisexual, small, without perianth; male flowers in upper part of spadix, with stamens entirely fused; female flowers at base of spadix, with superior, 1-celled ovary having an almost sessile stigma; male and female flowers separated by a band of sterile flowers. Fruit a many-seeded berry, densely packed and forming a fruiting head. Seeds ovoid to ellipsoid, less than 2 mm long, with copious endosperm.



Colocasia esculenta – 1, plant habit; 2, corm of dasheen type; 3, corm and cormels of eddoe type.
Source: PROSEA

Other botanical information *Colocasia* comprises 8 species from tropical Asia, and is classified in the tribe *Colocasieae*, together with e.g. *Alocasia*. There are 2 cultivar-groups of taro: Dasheen Group with a single large corm producing few small cormels, usually diploid ($2n = 28$); and Eddoe Group (frequently classified as var. *antiquorum* (Schott) F.T.Hubb. & Rehder) producing many large cormels, which are the main product, and usually triploid ($2n = 42$). Most taro cultivars in Africa belong to Eddoe Group.
Taro is sometimes confused with tannia (*Xanthosoma sagittifolium*) because of its similar appearance. A ready distinction lies in the junction of the leaf stalk with the blade: in taro the leaf is peltate, in *Xanthosoma* not.

Growth and development Planting is done usually in the beginning of the rainy season. After planting, growth of new roots and leaves starts after 2 weeks, the growth of suckers after 2 months. Growth of the corms also starts after about 2 months, in flooded taro after 3–5 months. There is a continuous turnover of leaves. After 4–5 months leaf area and mass reach their maximum, thereafter leaf stalks become shorter and leaf blades smaller and fewer. Most clones rarely flower and many do not flower at all. However, flowering can be induced by treatment with gibberellic acid. Picking of the leaves may start when the plants have about 6 leaves 3 months after planting. Intensive leaf harvesting may reduce corm size and yield, and number of suckers. Corms are ready for harvesting 8–10 months after planting for rainfed taro, and 9–12 months for wetland taro, although the corms reach their maximum weight a few months later.

Ecology Colocasia does best in tropical lowland in areas where annual rainfall exceeds 2000 mm. It is well adapted to high temperatures and relative humidity. Most types respond well to fairly stable temperature regimes of 21–27°C. Taro is rather tolerant to shade and for that reason suitable as intercrop under coconut, cocoa or coffee. Eddoe types are more resistant to drought and low temperatures than dasheen types, and the former are grown successfully as far north as Korea and Japan. Taro can withstand highly reduced soil conditions. It is mainly found in marshy areas and on river banks in savanna areas. It can be grown under dryland and flooded conditions, each requiring adapted cultivars. Cultivars

adapted to wet soil conditions withstand flooding without damage provided the water is not stagnant. Flooded cultivation is more intensive and requires greater attention than dryland cultivation. Under flooded conditions, the water level should not rise to a depth of more than 5–8 cm; with this method it takes longer to mature in comparison to dryland taro, but yields are higher. Eddoe types prefer well-drained loamy soils, and dasheen types grow best where the soil is heavy and has high moisture-holding capacity. A pH of 5.5–6.5 is optimal. Some cultivars tolerate high soil salinity.

Propagation and planting Taro is propagated vegetatively. It is sometimes difficult to keep planting material in a healthy condition during the dry season or periods of drought. Essentially 4 types of planting material are used: side suckers growing from the main corm, small unmarketable cormels (60–150 g), corm pieces, and setts or 'huli', i.e. the apical 1–2 cm of the main corm with 15–20 cm of the leaf stalks attached. In Ghana planting is mainly by use of either young suckers or mature setts cut from harvested corms. Planting material must be taken from healthy plants. Cormels are planted at a depth of 5–7.5 cm. Planting on ridges facilitates harvesting. For upland cultivation in the Philippines, furrows 30 cm deep and 80 cm apart are prepared. In flooded culture fields are ploughed, puddled and carefully levelled. Planting is done after draining the field or into 2–5 cm of standing water. The planting distance is 50–80 cm in the row and 70–120 cm between rows. For breeding purposes taro can be propagated by seed.

Management In tropical Africa upland taro is often intercropped with other vegetables. In Ghana farmers normally intercrop taro with sugar cane and at times with maize before complete flooding of the field. In Hawaii taro is grown continuously for several years in flooded fields. After a few years the fields are dried and planted with tomato, cucumber or capsicum pepper before the field is returned again to flooded taro. In South-East Asia, upland taro is often grown on dykes of paddy fields.

Taro requires good soil fertility and adequate organic matter. Flooded taro requires greater quantities of fertilizer for maximum yields than upland taro. Potash is particularly important and the crop also has a relatively high calcium requirement. General recommendation for taro is 40–80 kg/ha N, 15–30 kg/ha P and 50–100 kg/ha K. Some farmers in Ghana use organic manure (mainly from poultry) resulting in appreciable yields. Since the crop grows best in conditions where water is non-limiting, water management is a key factor. In situations with abundant water availability, closer spacing is advised; also when taro is intercropped it can be planted closer. Weeding is necessary until the canopy closes; in flooded cultivation growth of weeds is limited, and they can be easily controlled mechanically.

Diseases and pests Taro blight (*Phytophthora colocasiae*) is a major wetland taro disease, causing purple to brown circular water-soaked lesions. It is the most devastating taro disease, particularly in the Pacific region, where it has caused considerable losses, e.g. in the Solomon Islands, which have resulted in the crop being partially replaced by sweet potato. This disease is partially controlled by use of copper- or phosphor-based fungicides, but spraying is tedious and costly. Increasing plant spacing or intercropping reduces losses. Resistance has been found in germplasm collections. Several species of *Pythium* cause taro soft rot, with wilting and chlorosis of leaves. Control is possible by use of healthy planting material, crop rotation and treating planting materials with fungicide. Sclerotium rot caused by *Sclerotium rolfsii* is characterized by stunting of the plant, rotting of corm and formation of many spherical sclerotia in the corm. Control is by soil drenching. In both flooded and upland taro, dark brown spots that appear in older leaves are caused by *Cladosporium colocasicola* and *Phyllosticta colocasiae*. Dasheen mosaic virus and other viruses have been reported but are seldom serious. In the Pacific region the alomae virus disease causes serious damage. Symptoms start with a feathery mosaic on the leaves followed by crinkling and formation of outgrowths on the surface. Finally the entire plant becomes stunted and dies. Alomae disease is caused by the combined infestation by the taro large bacilliform virus (TLBV) and the taro small bacilliform virus (TSBV). Presence of TLBV only results in a milder form of the disease called 'bobone'. The viruses are transferred by a grasshopper and a mealy bug, respectively, but not by mechanical contact. In Hawaii, two diseases of unknown causative agents characterized by small, hardened portions in the lower third of the corm ('hard rot') and a soft rubbery corm which is low in starch content and exudes water when squeezed ('lohloli') are threatening. Attack by root-knot nematodes (*Meloidogyne* spp.) can result in

considerable crop loss. Control is by treating planting material with water at 40°C for 50 minutes, by the use of disease-free material or by soil fumigation.
Insect pest on taro may cause serious damage. Damage by *Hercothrips indicus* (synonym: *Heliothrips indicus*) thrips is shown as a silvery discoloration of the leaves and can result in severe leaf shedding. Adults of taro beetles (*Papuana* spp., e.g. *Papuana huebneri* and *Papuana woodlarkiana*) tunnel in the corm up to the growing point. Young plants wilt and die but older plants usually recover. This pest is reported in the Pacific and South-East Asia, but not in Africa. It can be controlled by applying insecticide in the planting holes. Severe losses have been suffered by a number of countries growing the crop (Polynesia, Hawaii, the Caroline Islands and Samoa), as a result of leafhoppers. Biological control and insecticide dusting are effective control measures. Larvae of the sweet potato hawk moth (*Agrius convolvuli*) defoliating the plant reduce corm quality.

Harvesting The harvest of the leaves may start 2 months after planting. Unfolding or young expanded leaves are preferred. From then on, continuous harvesting is assured provided sufficient water is available. Harvesting immature corms may start from 5 months onwards. Maturity of the crop depends on the cultivar and method of cultivation (upland or flooded). Dasheen types take about 8–10 months to mature while eddoe types mature in 5–7 months. Irrigated taro matures a few months later. Dasheen types may be ratooned, lifting the main tuber and leaving the small ones for successive harvests. Maturity indicators are yellowing of the leaves and a slight lifting of tubers. Commercial growers in Ghana allow the crop to remain over one year when prices are not favourable.

Yield The yield of leaves is not recorded. Corm yields are very variable. The average yield on a world basis is 5–6 t/ha, but a good crop on fertile soil gives at least 12 t/ha. and yields higher than 40 t/ha have been achieved in Hawaii.

Handling after harvest Leaves can only be stored for a few days. Corms can be stored under ambient condition for up to 6 weeks, provided they have not been bruised during harvesting. However, they often keep well for only 2 weeks. Corms of dasheen types can be stored at 10°C for up to 6 months. To avoid post-harvest problems, harvesting is best done when the corms are dry. For the fresh market, the corms are usually washed and the roots and fibres are discarded. In Ghana, the entire top parts are removed, whereas in Asia 30–45 cm of the leaf stalks are usually left attached. Pieces of the corm may be dried and stored as chips.
Storing planting material at about 2°C results in a delay of growth of 40–60 days; storage at 11–13°C and a relative humidity of 85–90% improves later growth. Corms for planting are normally left in the ground and are harvested when needed.

Genetic resources Genetic variability in taro is large in South-East Asia and New Guinea, but small in Africa and the Pacific region. Farmers in West Africa and elsewhere grow many clones. Loss of genetic diversity is minimal. Germplasm collections are maintained in several institutes in Asia and the Pacific region. The largest collection is held at the Bubia Agricultural Research Station, Bubia, Papua New Guinea.

Breeding The discovery of methods of flower induction in taro greatly facilitates breeding. Breeding programmes focus on resistance to diseases and pests, especially taro blight and taro beetles. Little research work has been done on breeding in Africa. In Nigeria techniques for promoting flowering and seed production using hand pollination have been successful. Tissue culture techniques for vegetative propagation have been developed in Hawaii and offer hope for obtaining virus-free planting material and for rapid multiplication of selected plants.

Prospects Taro is a vegetable with great potential. The importance of the leaves as leafy vegetable and the corms as relish is increasing. However, the importance of the corms as starchy staple food is declining since they are considered inferior to other roots and tubers. Taro is an excellent multipurpose food crop for subsistence agriculture and home gardens, giving food security. Its ability to grow under flooded conditions and to tolerate salinity makes it suitable for localities where few other crops grow. As such it merits more attention in research and breeding, focusing on disease resistances, yield and quality. For commercial production, separate cultivars need to be developed for harvesting leaves or corms.

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Sources of illustration Purseglove, J.W., 1972; Wilson, J.E. & Siemonsma, J.S., 1996.

Authors O. Safo Kantanka

COMMELINA AFRICANA L.

Protologue Sp. pl. 1: 41 (1753).

Family Commelinaceae

Vernacular names Yellow commelina, wandering Jew, dayflower (En). Comméline, comméline africaine (Fr). Kongwa (Sw).

Origin and geographic distribution *Commelina africana* is indigenous and widespread in Africa, occurring from Senegal to Ethiopia, and south to South Africa. It occurs also in Saudi Arabia, Yemen and Australia.

Uses In Kenya, Uganda and Tanzania the leaves are cooked and eaten as a vegetable. They are chopped and boiled in water or in fresh or sour milk. Sesame seeds and groundnut paste are added for flavour and consistency. This vegetable is eaten with the staple food as a substitute for more preferred vegetables.

Many other uses are reported for *Commelina africana*. In Kenya and Tanzania the leaves are fed to livestock, especially pigs and rabbits. The flowers provide bee forage. In Kenya an infusion of the plant is used as a wash to reduce fever, and pounded stalks are used to treat colds and coughs in children. Fluid from the spathes is applied locally to cure eye diseases. The Zulu of South Africa bathe the body, especially of a child, with a cold infusion in cases of restless sleeping. Similarly, an infusion of the leaves is sprinkled over the resting place of a restless child in Zimbabwe. The Sotho in southern Africa take a decoction of the plant with *Tephrosia capensis* Pers. for treatment of a 'weak heart' and nervousness. In DR Congo the root is used for the same purpose. The plant cooked with *Haplocarpha scaposa* Harv., *Helichrysum pilosellum* (L.f.) Less. or the root of *Cotyledon decussata* Sims is given by Sotho as medicine to young women to cure infertility. Also, an infusion of the plant is drunk and its ash is rubbed over the loins as a fertility charm. In Zimbabwe and South Africa a concoction of the root is used as treatment for venereal diseases and to treat women with menstrual cramps. This preparation is also used for pelvic pains and bladder complaints.

Botany Perennial herb with tuberous fusiform fleshy roots; stem creeping or straggling. Leaves arranged spirally, simple; leaf sheaths 0.8–3 cm long, with purple tinge, ciliate along the free margins; blade generally lanceolate, 6–11.5 cm × 1.2–2.2 cm, apex acute, glabrous except for the ciliate margins, rarely sparsely hairy, veins parallel. Inflorescence a leaf-opposed cyme; peduncle 8–40 mm long; spathe 0.9–2.4 cm long, margins free, glabrous except for the ciliate margins. Flowers bisexual, zygomorphic, yellow, rarely protruding from the spathe; lower petal linear-lanceolate, c. 5 mm × 2 mm, paired petals with claw 3–4 mm long, lamina broader than long, c. 4 mm × 6 mm; upper three stamens sterile, with cross-shaped anthers, medial stamen with filament 4–6 mm long and anther 1.5–2 mm long, the two lateral (lower) stamens with smaller anthers. Fruit a capsule 5–6 mm long, 3-celled, 3–5-seeded, the 2 ventral locules each 1(–2)-seeded (by abortion of the lower ovules) and dehiscent, the dorsal locule 1-seeded, indehiscent. Seeds variable in size, cylindrical-rectangular in outline, 2.2–3.5 mm × 1.3–2 mm, dark brown; testa rough (farinose granules) and pitted; hilum small, round.

Commelina africana is a variable species, in which many varieties are distinguished. The typical variety, var. *africana*, is a cultivated plant grown as a vegetable. *Commelina africana* is easily distinguished from the other *Commelina* species by its yellow instead of blue, purplish or pink flowers. The flowers open from 7–10 a.m.

Ecology *Commelina africana* occurs in secondary growth and disturbed localities, and as a weed on farms. In Senegal it grows in marshes. After the onset of the rains, the plant sprouts earlier than other plants and it is therefore useful as a fodder plant after prolonged drought. The same applies for its use as a vegetable; it is available earlier than commonly cultivated species.

Management In Uganda and Tanzania *Commelina africana* is not cultivated or protected by local people. It is common as a weed and therefore easily accessible. The leaves are collected in the rainy season for immediate use. They are not stored.

Genetic resources and breeding No germplasm collections or breeding programmes are known to exist for *Commelina africana*. Because of its abundance in Africa, there is no danger of genetic erosion.

Prospects Despite its multiple uses, the plant is reported not to be marketed in Tanzania. It is not a very popular vegetable. Prospects for its development as a vegetable crop seem bleak.

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Authors W.J. van der Burg

COMMELINA BENGHALENSIS L.

Protologue Sp. pl. 1: 41 (1753).

Family Commelinaceae

Chromosome number $2n = 22$

Synonyms *Commelina pyrrhoblepharis* Hassk. (1867).

Vernacular names Blue commelina, venus' bath, Benghal dayflower, tropical spiderwort (En). Commeline, comméline (Fr). Trapoeraba (Po). Kongwa, kafula, mpovupovu (Sw).

Origin and geographic distribution *Commelina benghalensis* is originally an Old World species, and is naturalized in the Americas and Hawaii. It occurs throughout tropical Africa from Cape Verde and Senegal to Ethiopia, and south to South Africa; it also occurs in Madagascar and the Mascarene Islands.

Uses In parts of West Africa, e.g. Côte d'Ivoire and Ghana, the leaves of *Commelina benghalensis* are cooked and eaten as a vegetable. The leaves are mucilagenous. In Kenya young leaves are eaten as a relish; older leaves are regarded as too acidic and bitter to use. In Kenya, Uganda and Tanzania the leaves and stems are chopped and cooked alone or with other vegetables such as *Bidens pilosa* L. or *Cleome hirta* Oliv. It is also reported as a vegetable in Ethiopia. In Indonesia the leaves and young tops are occasionally steamed and eaten as a vegetable, and in the Philippines they are eaten cooked. In India the leaves are eaten as famine food.

In Sudan and eastern Africa the plants are grazed by domestic stock, at the same time providing part of the cattle's need for water. In northern Ghana it is a favourite feed for pigs and poultry; in Tanzania it is given to animals, especially pigs and rabbits. The flowers provide bee forage. In southern Africa however, its use as pig feed is restricted to times of scarcity as it is thought to cause a sort of 'measles' in the animals. There may be edaphic or genetic differences causing such differences in properties, but these may also originate from misidentifications, because most *Commelina* species resemble each other very closely.

In southern Nigeria the plant is used as a poultice for sore feet. In East Africa the sap of *Commelina benghalensis* leaves and stems is used to treat ophthalmia, sore throat and burns, and the liquid contained in the flowering spathe is used to treat eye complaints in Zanzibar. In Uganda and Tanzania the sap is used topically against thrush in infants, and in Tanzania a solution of pounded leaves soaked in warm water to treat diarrhoea. In southern Africa *Commelina benghalensis* is used to counter infertility in women, and a decoction of the root is used for the relief of stomach disorders. In India it is said to be beneficial for leprosy, and in the Philippines it is used as an emollient suppository for strangury. In Rajasthan (India) sheep with jaundice are treated with a mixture of the plant with whey and common salt.

The rhizomes are starchy and mucilaginous. In India and Sudan they are commonly cooked and eaten, and are said to be a wholesome food. In India and China a dye is obtained from the sap of the flowers.

Properties Dry leaves of a sample of *Commelina benghalensis* from Bouaké, Côte d'Ivoire, contained per 100 g: protein 13.6 g, fat 2.1 g, carbohydrate 58 g, fibre 41 g (Busson, 1965). All aboveground parts are astringent and contain hydrocyanic acid. *Commelina benghalensis* has given negative results in tests for antibacterial effects.

Botany Perennial herb with tuberous fusiform fleshy roots; stems erect or creeping-ascending, often with subterranean cleistoga-

Commelina benghalensis – 1, flowering stem; 2, inflorescence; 3, opened spathe with fruits; 4, seed.
Source: PROSEA

mous flowers. Leaves arranged spirally, simple; sheath 0.5–3 cm long with purple veins, ciliate with purple 3–7 mm long bristles along free edges, rarely over the surface, otherwise glabrous or with hooked hairs; blade generally broadly lanceolate, 9–12 cm × 3–5 cm, pseudopetiole 3–15 mm long with a few purple or white bristles 3–7 mm long, apex acute or acuminate, pubescent or glabrous, veins parallel. Inflorescence a leaf opposed, falsely terminal cyme; peduncle up to 6 mm long; spathe funnel-shaped 1–2 cm long, margins completely fused, pubescent with short hooked hairs and sparsely pilose with straight hairs. Flowers bisexual, zygomorphic, protruding from the spathe when flowering, with pedicel 4–7 mm long, reflexed and enclosed in the spathe when fruiting; petals blue, lower petal smaller than the 2 upper petals, these with claw 4–5 mm long, lamina 8 mm × 10 mm; upper three stamens sterile, with cross-shaped, yellow anthers, medial stamen with filament 5–7 mm long and fertile, blue anther c. 2 mm long, the two lateral (lower) stamens with smaller fertile, blue anthers c. 1.4 mm long. Fruit a capsule 4.5–5.5 mm long, 3-celled, 3–5-seeded, the 2 ventral locules each 1(–2)-seeded, dehiscent, the dorsal locule 1-seeded, delayed or immediately dehiscent. Seeds variable in size, cylindrical-rectangular in outline, 2–5.5 mm × 1.5–2.2 mm, brown; testa reticulate with tuberculate ridges, provided with farinose granules; hilum normally linear, 1–3 mm long, not reaching the ends.

Blue-flowered *Commelina* species such as *Commelina benghalensis* and *Commelina diffusa* Burm.f. are easily confused. Both species are common throughout Africa. The properties attributed to one species may therefore also be valid for the other. In East Africa *Commelina imberbis* Ehrenb. ex Hassk. and *Commelina latifolia* Hochst. ex A.Rich. are also used as a vegetable. *Commelina zambesica* C.B.Clarke is used as a vegetable on Pemba Island (Tanzania).

The flowers of *Commelina benghalensis* open from 8 a.m. to noon.

Ecology *Commelina benghalensis* is common in disturbed areas, at forest edges, along roadsides, in secondary regrowth and fields, on waste ground and in home gardens. It can withstand prolonged drought. It is a very serious weed on farms; in Benin it is reported to be a noxious weed in cotton fields.

Management In Tanzania *Commelina benghalensis* is not cultivated or protected by local people. The leaves are collected during the early flush of the rainy season for immediate use. They are not stored. The plants are said to produce 14,000 seeds per plant above ground, and fewer in the soil (cleistogamous flowers), but the latter germinate to a high degree, and weed control is therefore cumbersome. It is a weed in both the drier north of Benin (where it may have an annual life cycle) and in the more humid south. It is a serious weed in other regions of the world as well as is illustrated by its appearance on the federal noxious weed list of the United States.

Genetic resources and breeding Because of its abundance and weedy nature, there is no danger of genetic erosion for *Commelina benghalensis*.

Prospects Despite its several uses, the plant is reported not to be marketed in Tanzania. The bleak prospects of commercialization as a vegetable do not seem to justify domestication research.

Major references Ahanchede, A. & Gasquez, J., 1992; Burkill, H.M., 1985; Busson, F., 1965; Isa Ipor, 2001; Ruffo, C.K., Birnie, A.

& Tengnäs, B., 2002; Watt, J.M. & Breyer-Brandwijk, M.G., 1962.

Other references Alam, N. & Sharma, A.K., 1984; Cufodontis, G., 1962–1969; Fynn, D.F., 1999; Irvine, F.R., 1930; Kelbessa, E. & Faden, B., 1997; Mathias, E., Rangnekar, D.V. & McCorkle, C.M., 1999; van den Bergh, M.H., 1993; Vanden Berghen, C., 1988; van Wyk, B.E. & Gericke, N., 2000.

Sources of illustration Isa Ipor, 2001.

Authors W.J. van der Burg

COMMIPHORA ROSTRATA Engl.

Protologue Annuario Reale Ist. Bot. Roma 7: 17 (1897).

Family Burseraceae

Origin and geographic distribution *Commiphora rostrata* is found in Ethiopia, Somalia and Kenya.

Uses The young leaves and shoots of *Commiphora rostrata* are edible. In Ethiopia and Somalia they are eaten raw, directly from the tree. The leaves are also used as a relish and cooked with other foodstuffs to add flavour. Bark and branches are sometimes used to prepare a tea. The stem pith is chewed to relieve thirst.

The leaves and young twigs are chewed to ease cough and chest problems. Bark or branches are chewed or taken as an infusion to relieve fever, colds and coughs. Juice from the bark is applied to the eyes to cure eye diseases. The Rendille people of northern Kenya apply unspecified plant parts to their livestock to repel parasites such as lice, fleas, mites and ticks. The twigs are used by the Turkana people as toothbrushes. Goats, sheep and camels browse the plants. The resin from the bark is used to glue feathers to arrow shafts. The powdered bark is added to water in new calabashes from bottle gourd and left for 3 days to give them a pleasant smell.

Properties The fresh leaves taste salty, acid and bitter. The acid taste is due to oxalic acid. The exudate from the bark is copious, very fluid and highly aromatic. It showed antimicrobial activity (against *Escherichia coli*, *Staphylococcus aureus* and *Pseudomonas aeruginosa*) and antifungal activity (against *Aspergillus* and *Penicillium*). The major components of the volatile fraction of the resin are 2-decanone (65%), 2-undecanone (24%) and 2-dodecanone (5%). The whole resin as well as the 3 pure constituents inhibited growth of fungi in vitro and showed a repellent effect on maize weevil (*Sitophilus zeamais*). The wood can support breeding populations of the larger grain borer (*Prostephanus truncatus*) and should therefore not be used in the construction of grain stores.

Botany Erect, dioecious shrub or small tree up to 4 m tall, sometimes prostrate or scandent; bark grey or dark purple; twigs tapering, spine-tipped. Leaves opposite, simple and entire; petiole 1–8 mm long; blade broadly elliptical to orbicular or obovate, 1–4.5 cm × 1–3.5 cm, apex emarginate, rounded or broadly pointed. Male inflorescence a branched cyme, 8–20-flowered, peduncle up to 15 mm long; female inflorescence 1–2-flowered, peduncle 6–8 mm long. Flowers unisexual, regular, 4-merous, dark red; pedicel filiform, up to 1.5 cm long; calyx c. 2 mm long with triangular lobes; petals linear, 4–6 mm long, with recurved tip; male flowers with 8 stamens, 4 long and 4 short; female flowers with superior, 2-celled ovary. Fruit a narrowly ovoid drupe 1.5–2 cm long including c. 0.5 cm long beak; stone ovoid, 8–10 mm long, covered by false aril.

Commiphora comprises about 190 species and occurs in tropical and subtropical Africa, Asia and South America. It is most abundant in the drier parts of eastern and southern Africa and in Madagascar. In Ethiopia and Eritrea a total of about 50 species has been recorded, in Madagascar about 20. Several species of *Commiphora* are important for their gum resins.

Ecology *Commiphora rostrata* is widespread in open bushland, usually on sloping ground, in areas with an annual rainfall of 150–600 mm. It is found at altitudes of 80–1050 m and is frost tolerant. Flowering takes place before the leaves appear.

Management *Commiphora rostrata* can be propagated by stem cuttings or seed.

Genetic resources and breeding *Commiphora rostrata* is not uncommon and not threatened. No germplasm collections are recorded.

Prospects *Commiphora rostrata* will continue to contribute to the human diet in the drier areas of East Africa. The insect repellent properties of *Commiphora rostrata* and other *Commiphora* species justify further research.

Major references Beentje, H.J., 1994b; Kokwaro, J.O., 1993; Maundu, P.M., Ngugi, G.W. & Kabuye, C.H.S., 1999; UN-EUE, 2001a; Vollesen, K., 1989a.

Other references Baerts, M. & Lehmann, J., 2002c; Gillett, J.B., 1991; Kibata, G.N. &

Nang'ayo, F.L.O., 1997; Lwande, W. et al., 1992; McDowell, P.G. et al, 1988; Morgan, W.T.W., 1981; SEPASAL, 2003b.

Authors C.H. Bosch

CONVOLVULUS FARINOSUS L.

Protologue Mant. pl. 2: 203 (1771).

Family Convolvulaceae

Chromosome number $2n = 24$

Origin and geographic distribution *Convolvulus farinosus* is found in eastern Africa (Eritrea, Ethiopia, Kenya, Uganda, Tanzania), southern Africa (Malawi, Botswana, Zimbabwe, Mozambique, South Africa), Madagascar, Réunion, and in the western Mediterranean region.

Uses Young leaves of *Convolvulus farinosus* are collected from the wild, cooked alone or with other vegetables such as amaranth or cowpea, and eaten with a staple food. Coconut milk or pounded groundnuts are often added. *Convolvulus farinosus* is also used as a forage and ornamental.

Botany Perennial herb with numerous, long and slender, twining or prostrate, long-pubescent stems. Leaves alternate, simple; petiole up to 7 cm long; blade triangular-ovate to ovate, 3–11 cm × 4–6 cm, sagittate to cordate at base, apex obtuse, acute or apiculate, margin entire to shallowly crenate, shortly pubescent. Inflorescence an axillary, umbel-like cyme, 1–6-flowered; peduncle up to 6 cm long. Flowers bisexual, regular, 5-merous; pedicel up to 1.5 cm long; sepals ovate-circular to elliptical, 5–9 mm × 3–5 mm, often pubescent; corolla campanulate, 1–1.5 cm long, with narrow tube and mucronate lobes, white or pinkish-purple, pubescent at the middle of lobes and apices; stamens inserted at base of corolla tube, filaments unequal; ovary superior, 2-celled, style filiform, c. 4 mm long, stigmas 2, filiform. Fruit a globose capsule 5–8 mm in diameter, apiculate, glabrous, pale brown, enclosed by persistent calyx, dehiscent by 4 valves. Seeds usually 4, globose-trigonous, c. 4 mm × 2.5 mm, black, rugose.

Convolvulus comprises about 250 species, most of them in temperate and subtropical regions of the world, with only a limited number in the tropics. In tropical Africa about 24 species occur.

Ecology *Convolvulus farinosus* occurs in upland grassland and fields, at 1000–2000 m altitude. It sometimes behaves as a troublesome weed.

Genetic resources and breeding *Convolvulus farinosus* is widespread and not in danger of genetic erosion.

Prospects *Convolvulus farinosus* will remain a minor leaf vegetable, of local importance only when other vegetables are scarce.

Major references Gonçalves, M.L., 1987; Ruffo, C.K., Birnie, A. & Tengnäs, B., 2002; Verdcourt, B., 1963.

Other references Bosser, J. & Heine, H., 2000b; Deroin, T., 2001.

Authors P.C.M. Jansen

CORALLOCARPUS BAINESII (Hook.f.) A.Meeuse

Protologue Bothalia 8: 41(1962).

Family Cucurbitaceae

Synonyms *Corallocarpus sphaerocarpus* Cogn. (1888).

Origin and geographic distribution *Corallocarpus bainesii* is a native of Tanzania, Zambia, Mozambique, Zimbabwe, Botswana, Angola, Namibia and South Africa. Records for Madagascar and the Comores are erroneous and relate to *Corallocarpus poissonii* Cogn.

Uses The leaves and stems are eaten as a salad and as a palatable but stringy cooked vegetable by bushmen and other tribes in South Africa. The raw fruits are sweet and edible when ripe.

Properties There are no records on the leaf composition, but likely it is comparable to other dark green leaf vegetables. The roots are bitter and not eaten although those of closely related species are edible. The roots contain considerable amounts of cucurbitacin B, smaller amounts of cucurbitacin D and traces of cucurbitacin G and H. Cucurbitacins, which are known from many *Cucurbitaceae* and various other plant species, exhibit cytotoxicity (including antitumour activity) and anti-inflammatory and analgesic activities.

Botany Monoecious, perennial prostrate or scandent herb; older stems with smooth, brown, ridged bark; tendrils simple. Leaves alternate, simple; stipules absent; petiole 1.7–5.4 cm long; blade ovate, deeply palmately 5-lobed, deeply cordate at base, lobes broadly ovate to narrowly elliptical. Inflorescence a congested cluster, shortly racemose in male inflorescence, many-flowered. Flowers unisexual, regular, 5-merous, with 1 mm long receptacle, sepals lanceolate, 1 mm long, petals c.

1.5 mm long; male flowers with pedicels 1.5–4.5 mm long, stamens 5; female flowers sessile, with inferior, 1-celled ovary, smooth, glabrous. Fruit a sessile, shortly ellipsoid capsule 8–9 mm × 6–6.5 mm, in a cluster, bright red, c. 6-seeded. Seeds ovoid or pyriform, up to 4.5 mm × 3 mm × 2.5 mm, smooth or verruculose.

Corallocarpus comprises about 10 species and is placed in the tribe *Melothrieae*. The genera *Corallocarpus* and *Kedrostis* are closely related. *Corallocarpus welwitschii* (Naud.) Hook.f. ex Welw. closely resembles *Corallocarpus bainesii* but the former has stalked fruits with an acute apex, and its roots are edible. They are further separated by their distinct ecological requirements.

Ecology *Corallocarpus bainesii* occurs in deciduous woodland and bushland at altitudes of 350–1550 m. In Namibia and Botswana it is restricted to arid sandy areas and is replaced in the remainder of these countries by *Corallocarpus welwitschii*.

Management *Corallocarpus bainesii* is exclusively collected from the wild.

Genetic resources and breeding Although fairly limited in distribution, no major threats of *Corallocarpus bainesii* have been identified.

Prospects *Corallocarpus bainesii* will remain of local importance only.

Major references Jeffrey, C., 1978; Meeuse, A.D.J., 1962; SEPASAL, 2003c; Story, R., 1958.

Other references Watt, J.M. & Breyer-Brandwijk, M.G., 1962.

Authors C.H. Bosch

CORCHORUS ASPLENIFOLIUS Burch.

Protologue Trav. S. Africa 1: 400 (1822).

Family Tiliaceae (APG: Malvaceae)

Chromosome number $2n = 14$

Vernacular names Wild Jew's mallow (En). Corète sauvage (Fr).

Origin and geographic distribution *Corchorus asplenifolius* is restricted to southern Africa, from Zambia southwards to South Africa and Swaziland. It is common at the fringes of the Kalahari desert.

Uses The mucilaginous texture of the foliage makes it a popular leafy vegetable when consumed together with a coarse staple food. In the past, ashes from this plant were used as a substitute for salt. The ash is said to dispel ants.

Production and international trade This vegetable is frequently collected from the wild during the rainy season for home consumption and for sale at local markets and urban centres (e.g. Bulawayo in Zimbabwe).

Properties The composition of *Corchorus asplenifolius* is probably comparable to that of *Corchorus olitorius*.

Adulterations and substitutes *Corchorus asplenifolius* can be replaced by okra or other *Corchorus* species found in the same region, especially *Corchorus tridens* L. and *Corchorus trilocularis* L.

Description Perennial herb with prostrate or suberect annual stems from a woody rootstock; stems glabrous or with a line of short, curly hairs, sometimes also with spreading hairs all around. Leaves alternate, simple; stipules setaceous, up to 1 cm long; petiole up to 1 cm long; blade lanceolate to almost linear, 1.5–8 cm × 0.2–1.5 cm, rounded or broadly cuneate and without setaceous appendages at base, acute at apex, margin coarsely or finely serrate or crenate, glabrous to densely hispid. Inflorescence a 1–3-flowered leaf-opposed fasciculate cyme, bracteate. Flowers bisexual, regular, usually 5-merous, shortly stalked; sepals free, linear to linear-oblanceolate, 6–10 mm long; petals free, oblanceolate to obovate, 6–10 mm long, yellow; stamens numerous; ovary superior, 3-celled, style up to 7 mm long. Fruit a slender cylindrical capsule up to 4 cm long and c. 2 mm wide, attenuated to a blunt, undivided apex, dehiscing by 3 valves, usually on twisted stalk, many-seeded. Seeds shortly cylindrical, 1.3–2 mm long, dark brown.

Other botanical information The genus *Corchorus* comprises an uncertain number of species, with estimates ranging from 40–100.

Corchorus asplenifolius – wild

Corchorus asplenifolius – rootstock with flowering and fruiting branch.
Redrawn and adapted by Iskak Syamsudin

Corchorus asplenifolius can be identified by its woody rootstock and often prostrate stems having narrow leaves and 3-valved capsules, often on twisted stalks. It resembles *Corchorus confusus* Wild, but this species usually has broader leaves and straight fruit stalks.

Growth and development *Corchorus asplenifolius* is one of the few perennial *Corchorus* species. In the dry season, it is often burnt down to ground level, but it sprouts again when the rainy season starts. It flowers mainly in the mid-rainy season, between December and March.

Ecology *Corchorus asplenifolius* occurs in open woodland and at the margins of seasonal swamps, usually on sandy soils.

Harvesting Tops of leafy stems and leaves are collected from the wild.

Handling after harvest Harvested leaves may be dried, made into powder and kept for use during the dry season.

Genetic resources Although *Corchorus asplenifolius* is not very widespread, it does not seem to be liable to genetic erosion because it is variable in morphology, locally common and may resprout from its woody rootstock left behind after collecting leafy stems.

Prospects *Corchorus asplenifolius* is a locally common and nutritious vegetable and as such a valuable wild plant. It only fetches low prices at markets, so there is little incentive to domesticate it and consider commercial production. The perennial habit may make it suitable for home garden planting for regular supply as a green vegetable for family consumption.

Major references Edmonds, J.M., 1990; Schippers, R.R., 2000; Tredgold, M.H., 1986; Wild, H., 1963; Wild, H., 1984.

Other references Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Wild, H., Biegel, H.M. & Mavi, S., 1972.

Sources of illustration Wild, H., 1984.

Authors R.R. Schippers

CORCHORUS OLITORIUS L.

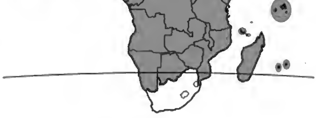
Protologue Sp. pl. 1: 529 (1753).

Family Tiliaceae (APG: Malvaceae)

Chromosome number $2n = 14$

Vernacular names Jew's mallow, jute mallow, krinkrin, tossa jute, bush okra, West African sorrel (En). Corète potagère, jute potager, mauve des Juifs, craincrain, krinkrin (Fr). Coreté, caruru da Bahia (Po). Mlenda (Sw).

Origin and geographic distribution The



Corchorus olitorius – wild and planted

geographical origin of *Corchorus olitorius*. is often disputed, because it has been cultivated since centuries both in Asia and in Africa, and it occurs in the wild in both continents. Some authors consider India or the Indo-Burmese area as the origin of *Corchorus olitorius* and several other *Corchorus* species. However, the presence in Africa of more wild *Corchorus* species and the larger genetic diversity within *Corchorus olitorius* point to Africa as the first centre of origin of the genus, with a secondary centre of diversity in the Indo-Burmese region. At present *Corchorus olitorius* is widely spread all over the tropics, and it probably occurs in all countries of tropical Africa.

In tropical Africa it is reported as a wild or cultivated vegetable in many countries. It is a leading leaf vegetable in Côte d'Ivoire, Benin, Nigeria, Cameroon, Sudan, Kenya, Uganda and Zimbabwe. Jew's mallow is also cultivated as a leaf vegetable in the Caribbean, Brazil, India, Bangladesh, China, Japan, Egypt and the Middle East. It is cultivated for jute production in Asia (India, Bangladesh, China) together with *Corchorus capsularis* L., but in Africa it is of no importance as a fibre crop, although the fibre may be used domestically.

Uses Jew's mallow is used as a leafy mucilaginous vegetable. The cooked leaves form a slimy sticky sauce, comparable to okra. In Nigeria this sauce is found suitable for easy consumption of starchy balls made from cassava, yam or millet. A powder prepared from dried leaves is used to prepare this sauce during the dry season. The immature fruits, called bush okra, are also dried and ground to a powder for the preparation of this slimy sauce. In East Africa several recipes exist, e.g. Jew's mallow may be cooked with cowpeas, pumpkin, cocoyam leaves, sweet potato, milk and butter, meat, and flavoured with peppers and lemon.

Jute has been the most widely used packaging fibre for more than 100 years because of its strength and durability, low production costs, ease of manufacturing and availability in large and uniform quantities. However, jute production is insignificant in Africa. The types of *Corchorus olitorius* that are used as a leaf vegetable are quite distinct from the types used for jute production.

Root scrapings of Jew's mallow are used in Kenya to treat toothache, a root decoction as a tonic, leafy twigs in Congo against heart troubles, an infusion from the leaves is taken in Tanzania against constipation, and seeds in Nigeria as a purgative and febrifuge.

Production and international trade Jew's mallow is one of the leading leafy vegetables in many countries and much cultivated and traded. No statistical data on production or marketing are available. International trade with neighbouring countries occurs, but is not registered. In Europe, Jew's mallow is sold in powder form as a Libanese product, under its Arab name 'meloukhia'.

The world jute production (combined data from *Corchorus olitorius* and *Corchorus capsularis*) has been stable over the past 40 years. In the period 1997–2001 it averaged 2.76 million t raw fibre per year. India and Bangladesh together produced more than 90% of the total.

Properties The composition of *Corchorus olitorius* leaves per 100 g fresh edible portion is: water 80.4 g (74.2–91.1), energy 243 kJ (58 kcal), protein 4.5 g, fat 0.3 g, carbohydrate 12.4 g, fibre 2.0 g, Ca 360 mg, P 122 mg, Fe 7.2 mg, β-carotene 6410 μg, thiamin 0.15 mg, riboflavin 0.53 mg, niacin 1.2 mg, ascorbic acid 80 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). This composition is in line with other dark green leaf vegetables, but the dry matter content of fresh Jew's mallow leaves is higher than average. The composition and especially the micronutrient content are strongly influenced by external factors such as soil fertility and fertilization. Nitrogen fertilizer greatly improves the micronutrient content, e.g. Fe, P, Ca, carotene and vitamin C.

The mucilaginous polysaccharide in the leaves is rich in uronic acid (65%) and consists of rhamnose, galactose, glucose, galacturonic acid and glucuronic acid in a molar ratio of 1.0:0.2:0.2:0.9:1.7 in addition to 3.7% acetyl groups.

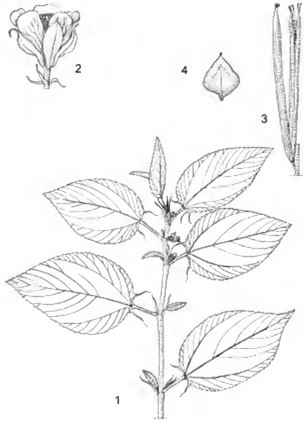
Jute fibres are obtained from the bast. The use is limited to coarse fabrics, because the length:diameter ratio of jute filaments is only 100–120, much below the minimum of 1000 required for fine spinning quality. Fibre cells are 2–2.5 mm long and 15–20 μm in diameter. Fibre cells are cemented together into filaments of up to 250 mm long. The tensile strength of jute is 395–775 MPa, the elongation at break is only 1–2%. Jute has a low ignition temperature of 193°C, posing a considerable fire hazard in warehouses.

Corchorus olitorius leaves contain antioxidative phenolic compounds, of which 5-caffeoylquinic acid is the most important. Some ionone glucosides have also been isolated from the leaves; they showed inhibitory activity on histamine release from rat peritoneal exudate

cells induced by antigen-antibody reaction. The seeds are poisonous to mammals and insects. They contain cardiac glycosides.

Adulterations and substitutes As ingredient of slimy sauces *Corchorus olitorius* can be replaced by other *Corchorus* species (also called Jew's mallow): the wild and cultivated *Corchorus tridens* L. and the wild species *Corchorus asplenifolius* Burch., *Corchorus fascicularis* Lam., *Corchorus trilocularis* L. and *Corchorus aestuans* L.

Description Erect annual herb up to 2(–4) m tall, usually strongly branched; stems reddish, fibrous and tough. Leaves alternate, simple; stipules narrowly triangular with long point; petiole (0.5–)1–7 cm long; blade narrowly ovate, ovate or elliptical, 4–15(–20) cm × 2–5(–11) cm, cuneate or obtuse and with setaceous appendages up to 2.5 cm long at base, acuminate to acute at apex, margin serrate or crenate, almost glabrous, usually shiny dark green, 3–7-veined from the base. Inflorescence a 1–4-flowered axillary fascicle, bracteate. Flowers bisexual, regular, usually 5-merous, shortly stalked; sepals free, narrowly obovate, 5–7 mm long; petals free, obovate, 5–7 mm long, yellow, caducous; stamens numerous; ovary superior, usually 5-celled, style short. Fruit a cylindrical capsule up to 7(–10) cm long, ribbed, with a short beak, usually dehiscing by 5 valves, many-seeded. Seeds angular, 1–3 mm long, dark grey. Seedling with epigeal germination; hypocotyl 1–2 cm long; cotyledons foliaceous, broadly elliptical to circular, 3–8 mm long.



Corchorus olitorius – 1, flowering branch; 2, flower; 3, fruits; 4, seed.
Redrawn and adapted by Iskak Syamsudin

Other botanical information The genus *Corchorus* comprises an uncertain number of species, with estimates ranging from 40–100. Two important cultivar-groups of *Corchorus olitorius* exist. The vegetable types are combined in Olitorius Group, characterized by a plant height lower than 2 m, often not more than 1 m, and a more or less heavily branched plant habit. The fibre types are classified in Textilis Group, with plant heights of 4(–5) m and plants only slightly branched at the top. Within Olitorius Group, there are numerous local cultivars, e.g. early and late flowering, and with differences in plant habit and leaf shape. In Nigeria, the popular 'Amugbadu' is reputed to be suitable for transplanting and harvest by repeated cuttings; it has finely serrate, elliptical-ovate leaves, whereas 'Oniyaya' has smaller and coarsely serrate leaves, is strongly branched and more suitable for direct sowing and once-over harvest. 'Géant de Bertoua' from Cameroon has very large, broadly ovate leaf blades. Cultivars with deeply and irregularly serrate leaves ('Incisifolius') can be found in Benin and Cameroon.

Growth and development Growth of *Corchorus olitorius* seedlings is fast. In short day conditions flowering starts about a month after emergence and continues for 1–2 months, depending on type and conditions. The flowers are usually self-pollinated, but cross-pollination up to 10% occurs. After about 3–4 months, the fruits are ripe, the leaves drop and the plant dies.

Ecology Wild plants of *Corchorus olitorius* grow in grassland and fallow or abandoned fields, often close to marshes, rivers and lakes, at up to 1250(–1750) m altitude. Jew's mallow thrives best under hot and humid conditions. In the savanna and Sahel zone, it performs best during the hot rainy season. It is cultivated where annual rainfall averages 600–2000 mm. The optimal temperature is 25–32°C. Growth stops below 15°C. Jew's mallow is a short-day species. In Nigeria a daylength of 12.5 hours caused a much stronger vegetative growth expressed in weight of roots, stems

and leaves than a day length of 11.5 hours, but the fruit and seed production was higher at a photoperiod of 11.5 hours. Jew's mallow prefers sandy loam soils rich in organic matter and grows poorly on heavy clay.

Propagation and planting In general farmers have no access to improved seed, but harvest their own. They keep a few plants for that purpose in their garden or field until fruit maturity. For a good seed yield of 25 g per plant, a spacing of 50 cm between and within the row is recommended. Commercial seed production may be 600 kg/ha. The seed is ripe when all the leaves have dropped. For own on-farm seed production, the stems with fruits are harvested, and after drying in the sun they are kept until the next season. In villages in the north of Côte d'Ivoire, the women conserve the fruits in the kitchen above the fireplace. Fruits on abandoned plants in the field also still contain viable seed until the next rainy season. These fruits open at the onset of the rains and the seeds spread. Well-dried seed keeps a high germination capacity for several years. One g contains about 470 seeds. Fresh and sometimes old seed shows dormancy caused by impermeability of the seed coat. This is a major problem for Jew's mallow cultivation. To suppress the dormancy, it is recommended that the seed tied in a piece of cotton cloth be immersed for 5 seconds in almost-boiling water before sowing. Another method is scarification with sandpaper.

In traditional field cultivation, the farmers broadcast seed without any consideration concerning the optimal density. They often grow Jew's mallow in association with other vegetables or food crops such as okra, tomato, watermelon, groundnut or yam.

Peri-urban vegetable farmers produce Jew's mallow on beds in monoculture. Direct sowing is mainly applied for once-over harvest by uprooting or low cutting at soil level. Sowing is done in lines 30–50 cm apart and with spacing 10–15 cm in the rows. For the more common harvesting by repeated cuttings, 10–20 g seed per 10 m^2 is sown in a nursery in well-loosened soil. When the seedlings are 5–10 cm tall, they are transplanted at a spacing of 10–20 cm in the row and 30–50 cm between the rows. In trials in Ghana the highest yield, 50 kg of marketable shoots or 29 kg of edible leaves per 10 m^2, was obtained with a spacing of 10 cm × 45 cm.

Management Jew's mallow is usually grown as a rainfed crop without much care. In peri-urban production the growers practise manual irrigation during the dry season, at least 6 mm daily. Organic fertilizer may be applied at up to 20 t/ha. A basal application with NPK (e.g. 15–15–15 at 400 kg/ha) and a side dressing with nitrogen are recommended for an optimal yield. Nitrate fertilizer gives better results than ammonium-based ones.

Diseases and pests Jew's mallow is rather resistant to diseases and pests. *Sclerotium rolfsii* causing foot rot and wilting is sometimes a problem. *Curvularia* species cause black leaf spots, and *Cercospora* circular leaf spots. These fungal diseases are kept under control by cultivation on well-drained beds and wide spacing. A virus disease transmitted by leaf hoppers and causing leaf deformation and retarded growth was reported from Nigeria.

The most damaging pests are grasshoppers (*Zonocerus variegatus*), caterpillars (*Acrea* spp.), army worm (*Spodoptera littoralis*) and flea beetles (*Podagrica* spp.). During the dry season, red spider mites (*Tetranychus cinnabarinus*) often attack the leaves. Control by spraying with recommended pesticides is rarely applied.

Jew's mallow is very susceptible to root-knot nematodes (*Meloidogyne* spp.). Methods of control include crop rotation, avoiding other crops susceptible to root-knot nematodes for at least one year, and taking care to ensure a high organic matter content of the soil.

Harvesting The first harvest by cutting shoots 20–30 cm long may take place 4–6 weeks after transplanting at a height of 10–20 cm above the ground. This cutting stimulates the development of side shoots. Subsequently every 2–3 weeks a cutting may take place, in total 2–8 cuttings. For a once-over harvest from a direct sown crop the plants are uprooted or cut at ground level when they are 30–40 cm tall, 3–5 weeks after emergence and before development of fruits. The plants are bundled for marketing. In intercropping systems farmers tend to harvest at irregular intervals. Wild Jew's mallow is picked from the vegetation when required, usually for home consumption.

A crop planted for jute production is generally harvested 100–120 days after sowing when the plants are in the early fruit stage.

Yield In Nigeria a yield of 20–25 kg per 10 m^2 bed may be expected from 3–9 cuttings of 'Amugbadu' during a period of 3–4 months. In an experiment in Cameroon a yield of 38 t/ha was obtained from a well-fertilized field of cultivar 'Ewondo'. Farmers however, usually ob-

tain average yields of 5–15 t/ha.
The world average jute yield is about 1.9 t of raw fibre per ha, but yields of 5 t/ha have been obtained in Bangladesh with improved cultivars grown under optimal agronomic conditions.

Handling after harvest Jew's mallow leaves cannot be kept long. Mostly the product is sold on the harvest day, and it is constantly kept wet. If cooled to 20°C it can be kept for about 1 week, in cold storage for several weeks. If the leaves are dried and pounded to powder, the product can be kept for at least half a year.
Jute stems are retted in water for a period of (8–)15–20(–30) days to free the fibres from the bark. When retting is complete, the fibres are stripped manually from the stems, subsequently washed and dried, and then graded and packed.

Genetic resources The risk of genetic erosion is negligible because there is almost no commerce of seed of improved cultivars. At the Nigerian Horticultural Research Institute NIHORT at Ibadan, a collection of local types is maintained. The genebank of the Bangladesh Jute Research Institute in Dhaka has the mandate of world repository for germplasm of jute. It has a collection of almost 1500 *Corchorus olitorius* accessions through various germplasm collection projects in Asia and East Africa.

Breeding Farmers select the most vigorous plants with the best mucilaginous properties. When smaller leaves are required, farmers select for profuse branching. At NIHORT in Ibadan selections have been made for rapid early growth, large leaf size, dark green glossy leaves and late flowering. Hand crossing appeared difficult because of flower drop after emasculation.
Jute selection with the objectives of higher yield, finer fibre quality, disease resistance, early crop maturity and low photosensitivity has been practised for many years in Bangladesh and India and has resulted in several successful *Corchorus olitorius* cultivars.

Prospects Jew's mallow is a high quality leafy vegetable in market value, consumers' preference and nutritional value. Reliable seed of improved cultivars should become commercially available. It is recommended that local cultivars be collected and tested for useful characteristics including adaptation to various environments, resistance to diseases and yield. It seems impossible for Africa to compete in export markets for jute, in view of the excellent conditions for jute cultivation in Bangladesh and India.

Major references Burkill, H.M., 2000; Denton, L., 1997; Edmonds, J.M., 1990; Khandakar, A.L. & van der Vossen, H.A.M., 2003; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Schippers, R.R., 2000; Stevels, J.M.C., 1990; van Epenhuijsen, C.W., 1974.

Other references Akoroda, M.O., 1988; Grubben, G.J.H., 1977; M'bah-Ngami, A.G., 1998; Norman, J.C., 1992; Ohtani, K. et al., 1995; Purseglove, J.W., 1968; Singh, D.P., 1976; van der Zon, A.P.M. & Grubben, G.J.H., 1976; Westphal, E. et al., 1985.

Sources of illustration Bosser, J., 1987.

Authors L. Fondio & G.J.H. Grubben

CORCHORUS TRIDENS L.

Protologue Mant. pl. 2: 566 (1771).

Family Tiliaceae (APG: Malvaceae)

Chromosome number $2n = 14$

Vernacular names Jew's mallow (En). Corète à trois dents (Fr). Coreté. (Po). Mlenda. (Sw).

Origin and geographic distribution The genus *Corchorus* probably originates from Africa, with a secondary centre of diversity in the Indo-Burmese region. *Corchorus tridens* is widespread over tropical Africa and is also found in Nepal, Pakistan, India and Northern Australia. In Africa it occurs from Senegal in the west, east to Somalia and south to South Africa; it has been recorded for many countries. It is occasionally tolerated as a wild vegetable in crop fields with selective weeding, or grown in home gardens. It has some importance as a

Corchorus tridens – wild and planted

vegetable in Benin, Cameroon, Kenya, Mozambique, Niger, Nigeria and South Africa.

Uses The leaves are used as a vegetable in stews eaten with starchy staple foods, and in soups and sauces. They taste more bitter than those of *Corchorus olitorius* L., the more commonly cultivated Jew's mallow. Cooked leaves become mucilaginous and this drawing property is accentuated by addition of the filtrate of ashes. In West Africa and Malawi the plant has been used for its stem fibres, e.g. for fishing lines and rough cordage. *Corchorus tridens* is grazed by livestock.

Production and international trade *Corchorus tridens* is utilized locally where it is collected as spontaneous vegetable in fallow land or where it is grown in home gardens and occasionally sold at the market. There are no statistical data, nor is there any international trade.

Properties The composition of *Corchorus tridens* is probably comparable to that of *Corchorus olitorius*.

Adulterations and substitutes Okra and other *Corchorus* species are used in the same way: the cultivated *Corchorus olitorius* L. and the wild species *Corchorus asplenifolius* Burch., *Corchorus fascicularis* Lam., *Corchorus trilocularis* L. and *Corchorus aestuans* L.

Description Annual herb up to 1 m tall, usually erect and branched; stems reddish, fibrous and tough, often somewhat woody. Leaves alternate, simple; stipules setaceous, up to 1 cm long; petiole up to 1.5(–2.5) cm long; blade narrowly ovate to lanceolate or narrowly elliptical, 2.5–10(–12) cm × 0.5–3(–4.5) cm, rounded and with setaceous appendages up to 1 cm long at base, rounded, acuminate or acute at apex, margin serrate or crenate, sparsely pubescent, usually non-shiny and pale green, 3(–5)-veined from the base. Inflorescence a 1–4-flowered leaf-opposed fasciculate cyme, bracteate. Flowers bisexual, regular, usually 5-merous, shortly stalked; sepals free, narrowly elliptical to narrowly obovate, 3–5 mm long; petals free, narrowly obovate to narrowly oblanceolate, 4–5 mm long, yellow, caducous; stamens up to 20; ovary superior, 3-celled, style short. Fruit a slender cylindrical capsule up to 4 cm long and up to 2 mm wide, slightly ribbed, with 3 small spreading horns at apex, dehiscing by 3 valves, many-seeded. Seeds cylindrical, often somewhat quadrangular, c. 1.5 mm long, dark brown.

Other botanical information The genus *Corchorus* comprises an uncertain number of species, with estimates ranging from 40–100. *Corchorus tridens* can be easily identified by the 3 small horns at the top of the slender capsules, which split at maturity with 3 valves. It seems closest to *Corchorus aestuans*, but this species has winged fruits.

Corchorus tridens – 1, flowering and fruiting branch; 2, flower; 3, stem fragment with fruits. Redrawn and adapted by Iskak Syamsudin

Growth and development The plants grow rapidly in the rainy season and flowering occurs about 6 weeks after germination. The first leaves can be picked at about 40 days after sowing. Flowering occurs continuously and seeds mature at 90–110 days from sowing. Fruiting plants can be found throughout the year.

Ecology *Corchorus tridens* occurs in savanna, woodland and scrub vegetation, and often grows as a weed. It can be found up to 1700 m altitude, but is generally grown below 700 m. It is a hot season vegetable in dry areas. It is collected in the lowland African tropics throughout the year. Although it thrives best during the rainy season, it is rather drought resistant. It can tolerate a month without rainfall, but irrigation improves growth and yields. It also tolerates a high level of rainfall but is very sensitive to excess water when young.

Favourable temperatures range from 22–35°C and diurnal variations within this bracket encourage leaf development. *Corchorus tridens* can be grown in a range of soil types but well-drained, alluvial or sandy loams are preferable. A soil pH of 6.5–7 is favourable, but it tolerates a pH between 5.5–8.5.

Propagation and planting *Corchorus tridens* is predominantly collected from the wild and only occasionally cultivated. In cultivation, the same technology may be applied as for *Corchorus olitorius*. Seeds are sown directly on well-prepared, manured beds at the beginning of the wet season, broadcast or drilled in rows spaced at 20–30 cm. The seed rate is about 5 g per 10 m^2. The plants are thinned to 20 plants per m^2. Germination may be poor due to seed dormancy, but a short immersion in boiling water or soaking overnight in warm water speeds up germination and makes it less erratic. The seeds retain their viability for 8–12 months when stored in well-sealed jars.

Management Weeding must be done early; thinning is done prior to the first harvest. Supplementary irrigation in a drought period is beneficial. Organic fertilizer may be applied at up to 20 kg per 10 m^2 bed. A basal application with NPK, e.g. at 200 g per 10 m^2, followed by a side dressing with nitrogenous fertilizer is recommended for optimum yield.

Diseases and pests Major diseases include wilting by *Sclerotium rolfsii* and leaf spot by *Cercospora corchori*. *Corchorus tridens* is susceptible to red spider mites (*Tetranychus urticae*), yellow mites, leaf beetles (*Podagrica sjostedji*), sweet potato butterfly (*Acraea acerata* and *Acraea terpsichore*) and root-knot nematode (*Meloidogyne* spp.).

Harvesting About 40 days after sowing, when the plants have made adequate foliage, harvesting is done every fortnight by topping leafy shoots. Harvesting stops when the plants are about 80 days old, when no new leaves are formed. Topping encourages branching and hence gives a higher yield. As flowering occurs concurrently with new leaf formation, flowers of leafy shoots are removed. Fruits become brown when mature and are harvested before shattering the seeds; they are threshed and winnowed to obtain seeds for sowing.

Yield The leaf yield is about 5–8 kg per 10 m^2 and is much reduced during the dry cool season.

Handling after harvest Harvested leaves may be dried, made into powder and stored for a long period.

Genetic resources *Corchorus tridens* is widespread and occurs in anthropogenic habitats, and thus does not seem liable to genetic erosion. There are no germplasm collections.

Prospects *Corchorus tridens* is an interesting vegetable in dry environments, occurring spontaneously, but it can also be cultivated in home gardens. Seeds are easily procured and stored. It is a well-liked vegetable, easily preserved as dried leaf, nutritious and important in food security policy. Germplasm collection and research of *Corchorus tridens* should be promoted. However, in peri-urban cultivation it cannot compete with the higher yielding *Corchorus olitorius*.

Major references Burkill, H.M., 2000; Edmonds, J.M., 1990; FAO, 1988; Oliveira, J.S. & de Carvalho, M.F., 1975; Schippers, R.R., 2000; Singh, D.P., 1976; Stevels, J.M.C., 1990.

Other references Figueiredo, E., 1995b; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Machakaire, V., Turner, A.D. & Chivinge, O.A., 2000; Purseglove, J.W., 1968; van der Zon, A.P.M. & Grubben, G.J.H., 1976; Vollesen, K. & Demissew Sebsebe, 1995; Wilczek, R., 1963; Wild, H., 1963.

Sources of illustration Stevels, J.M.C., 1990.

Authors N.A. Mnzava

CORCHORUS TRILOCULARIS L.

Protologue Syst. nat. ed. 12, 2: 369 (1767).
Family Tiliaceae (APG: Malvaceae)
Chromosome number $2n = 14$

Vernacular names Jew's mallow, wild Jew's mallow, bush okra (En). Corète à trois loges (Fr). Coreté (Po). Mlendo (Sw).

Origin and geographic distribution The genus *Corchorus* probably originates from Africa, with a secondary centre of diversity in the Indo-Burmese region. *Corchorus trilocularis* is widespread over tropical Africa and is also found in tropical and subtropical Asia and Australia. In Africa it occurs from Cape Verde and Mauritania in the west, to Somalia, Comoros, Madagascar and Mauritius in the east, and to South Africa in the south; it has been recorded for many countries.

Uses Young tender leaves of *Corchorus trilocularis* are cooked into a mucilaginous product that is either used as a sauce or as relish with maize or other cereal. It is popular because cooking does not take much time and requires only small amounts of fuel. In Western Uganda

Corchorus trilocularis – wild

people prefer the flowers to the leaves and cook them as a mucilaginous vegetable to be mixed with more coarse vegetables. Dried flowers are ground into a powder and kept for use in the dry season. The plants are grazed by animals including cattle. In Somalia the stem fibres are used for rope making.

Production and international trade Locally *Corchorus trilocularis* is a popular vegetable collected from the wild for home consumption and for sale at local markets. It is only rarely cultivated on a small scale.

Properties The composition of *Corchorus trilocularis* is probably comparable to that of *Corchorus olitorius* L.

Adulterations and substitutes *Corchorus trilocularis* can be replaced by okra or other *Corchorus* species, especially *Corchorus olitorius*. In drier regions it is mainly replaced by *Corchorus tridens* L.

Description Annual herb up to 1(–1.5) m tall, usually erect, sometimes with decumbent branches; stems fibrous and tough, often somewhat woody, often pubescent on one side. Leaves alternate, simple; stipules setaceous, up to 1.2 cm long, pubescent; petiole up to 0.5–2.5 cm long; blade ovate or oblong to lanceolate or narrowly elliptical, (2–)4–9(–13) cm × 0.5–3(–4) cm, rounded or broadly cuneate and with or without setaceous appendages up to 1 cm long at base, acute to obtuse at apex, margin serrate or crenate, usually pubescent on the veins, 3(–5)-veined from the base. Inflorescence a 1–3(–4)-flowered leaf-opposed fasciculate cyme, bracteate. Flowers bisexual, regular, usually 5-merous, shortly stalked; sepals free, narrowly lanceolate, (3–)6–10 mm long; petals free, oblanceolate, (3–)6–10 mm long, yellow, caducous; stamens up to 40(–60); ovary superior, 3(–4)-celled, style short. Fruit a slender cylindrical capsule up to 7(–8) cm long and up to 3 mm wide, slightly ribbed, with short beak at apex, scabrid, covered with stellate hairs when young, dehiscing by 3(–4) valves, many-seeded. Seeds oblong-ovoid, 1–1.5 mm long, dark brown to black.

Other botanical information The genus *Corchorus* comprises an uncertain number of species, with estimates ranging from 40–100. *Corchorus trilocularis* can be confused with *Corchorus tridens*, but the latter has distinctly spreading horns at the fruit apex. Older leaves of *Corchorus tridens* are less liked than those of *Corchorus trilocularis* because they become bitter with age, probably due to an increase in tannins. *Corchorus trilocularis* can also be confused with *Corchorus asplenifolius* Burch., especially when it is grazed or trampled and stems become decumbent, but the latter is a perennial herb with woody rootstock.

Growth and development Once conditions of adequate moisture and a temperature of approximately 25°C are met, *Corchorus trilocu-*

Corchorus trilocularis – 1, fruiting branch; 2, flower, front sepal and petal removed; 3, fruit; 4, seed.
Redrawn and adapted by Achmad Satiri Nurhaman

laris grows very fast. It has a short growing season, often no longer than 3–4 months. More luxuriant growth occurs in manured fields.

Ecology *Corchorus trilocularis* occurs in a wide range of habitats, from seasonally inundated land on clay soils and river banks to grassland, roadsides and disturbed places, and from black cotton soil to semi-arid sandy soils, as long as there is a warm season. It is most common in places with residual moisture such as clay plains, where it may colonize the entire area, becoming the most abundant species. It is commonly found as a weed in irrigated fields. It appreciates high temperatures as long as there is adequate moisture in the rooting zone.

Propagation and planting Only few people cultivate *Corchorus trilocularis* by broadcasting the seeds in their garden to produce a crop for home consumption.

Management Normally *Corchorus trilocularis* is collected from the wild or from fields, where it is left untouched during weeding. If cultivated, the same technology may be applied as for *Corchorus olitorius*.

Harvesting Shoot tips are plucked from wild plants from the moment that they are about 10 cm tall. These fresh shoots are most appreciated. Plucking of shoots continues until fruits start developing and from then on only new side shoots or individual young leaves are harvested.

Handling after harvest The produce is mainly sold fresh and offered at the market in heaps, often with flowers and young fruits present. The leaves are stripped from shoots that are no longer tender. Such leaves are often preserved in water to keep them fresh. Alternatively, leaves may be dried and kept for use during the dry season. Dried produce will only retain about 15–20% of its original weight. When drying conditions are less than ideal, its colour changes from green to blackish and its value becomes much reduced. Sun-drying should be done on clean sheets and the produce turned over regularly to obtain a uniform and green product. Dried leaves will retain their quality for up to one year as long as they are kept dry.

Genetic resources *Corchorus trilocularis* is widespread and occurs in anthropogenic habitats, and thus does not seem liable to genetic erosion. There are no germplasm collections.

Prospects *Corchorus trilocularis* is locally common and offered at the market at low prices. *Corchorus olitorius* is preferred for cultivation because of its much higher yield capacity, thus there is little incentive to produce *Corchorus trilocularis* commercially.

Major references Edmonds, J.M., 1990; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Wild, H., 1963; Wild, H., 1984.

Other references Bosser, J., 1987; Burkill, H.M., 2000; Figueiredo, E., 1995b; Schippers, R.R., 2000; Vollesen, K. & Demissew Sebsebe, 1995; Wilczek, R., 1963.

Sources of illustration Bosser, J., 1987; Vollesen, K. & Demissew Sebsebe, 1995.

Authors R.R. Schippers

COSTUS PHYLLOCEPHALUS K.Schum.

Protologue Bot. Jahrb. 15: 420 (1893).

Family Costaceae

Origin and geographic distribution *Costus phyllocephalus* has a relatively restricted distribution and has been recorded in southern DR Congo and northern Angola.

Uses In Bas Congo (DR Congo) young leaves and shoots of *Costus phyllocephalus* are collected from the wild and eaten raw as a salad. They have a pleasant, refreshing and slightly acid taste.

Botany Perennial herb with rhizome and terete, glabrous stem up to 50 cm long. Leaves arranged spirally, simple; sheath tubular, closed, with ligule up to 3 cm long; petiole up to 0.5 cm long; blade lanceolate to oblong-obovate, 8–17 cm × 4–6.5 cm, with an acuminate tip, glabrous. Inflorescence a terminal head c. 5 cm in diameter, with large bracts having a blade up to 7 cm long. Flowers bisexual, zygomorphic, 3-merous; calyx tubular, c. 1.5 cm long, toothed; corolla 3-lobed, lobes fused at base, unequal, lower lobe (lip) c. 5 cm × 5 cm, pink with white throat; stamen 1, petaloid, c. 3 cm long; ovary inferior, 3-celled. Fruit a capsule crowned by the persistent calyx, many-seeded. Seeds with aril.

Costus comprises about 90 species and can be found throughout the tropics, tropical America being richest in species. In tropical Africa approximately 30 species occur. The leaves of *Costus afer* Ker-Gawl., *Costus lucanusianus* Joh.Braun & K.Schum. and *Costus spectabilis* (Fenzl) K.Schum. are also eaten in Bas Congo, but the former 2 are more important medicinally and the latter is preferred as an ornamental. The young shoots of *Costus lucanusianus* are cooked and eaten in Gabon and also have an acidulous taste.

Ecology *Costus phyllocephalus* can be found

in the undergrowth of lowland forest, often in humid localities along streams.

Genetic resources and breeding The range of distribution of *Costus phyllocephalus* is limited, rendering it susceptible to genetic erosion. However, there is insufficient information available to make any pertinent conclusions or recommendations.

Prospects Locally *Costus phyllocephalus* is a popular vegetable, and it merits further examination. It might be an interesting ornamental because of its attractive flowers and the comparatively small plant size.

Major references Latham, P., 2002.

Other references Daeleman, J. & Pauwels, L., 1983; Konda, K. et al., 1992.

Authors W.J. van der Burg

CRASSOCEPHALUM CREPIDIOIDES (Benth.) S.Moore

Protologue Journ. Bot. 50: 211 (1912).

Family Asteraceae (Compositae)

Chromosome number $2n = 40$

Synonyms *Gynura crepidioides* Benth. (1849).

Vernacular names Ebolo, thickhead, redflower ragleaf, fireweed (En). Ebolo (Fr). Eyukula (Po).

Origin and geographic distribution *Crassocephalum crepidioides* occurs throughout tropical Africa, from Senegal east to Ethiopia and south to South Africa; it is also found in Madagascar and Mauritius. It was introduced and naturalized throughout tropical and subtropical Asia, Australia, the New Hebrides, Fiji, Tonga and Samoa, and locally in the Americas.

Crassocephalum crepidioides – wild

The leafy parts are widely used as a vegetable, e.g. in Sierra Leone, Ghana, Benin, Nigeria, Cameroon, DR Congo and Uganda, and also in Asia.

Uses The tender and succulent leaves and stems of ebolo are mucilaginous and are used as a vegetable in soups and stews, especially in West and Central Africa. It is much appreciated for its special flavour, which is sharp but not bitter. It is especially popular in south-western Nigeria, from where the originally Yoruba name 'ebolo' derives. Here the leaves are lightly blanched, excess water is drained off, and the leaves are then cooked with peppers, onions, tomatoes, melon and sometimes fish or meat to make soups and stews. In Sierra Leone the leaves are also popular and are made into a sauce with groundnut paste. In Australia ebolo is eaten as a salad green, either cooked or raw.

In southern Nigeria, the leaves of ebolo are used to treat indigestion. In DR Congo leaf sap is given to treat upset stomach, in Uganda it is used as a treatment for fresh wounds. A leaf lotion or decoction is used to treat headache in Nigeria, and in Tanzania a mixture of the leaf sap of *Crassocephalum crepidioides* and *Cymbopogon giganteus* Chiov. is used orally and externally for the treatment of epilepsy. In Tanzania the dried leaf powder is applied as a snuff to stop nose bleeding and smoked to treat sleeping sickness. Tannin found in the roots of the plant is used to treat swollen lips. The plants are readily eaten by livestock, and they are considered a useful green fodder for poultry. *Crassocephalum crepidioides* has been used successfully as a trap plant to collect adult corm weevils in banana plantations.

Production and international trade Ebolo leaves and shoots are produced principally for local markets in rural and urban areas. In south-western Nigeria they are found most commonly in markets during the rainy season. Statistical data on production and trade are not available.

Properties The nutritional composition of ebolo leaves per 100 g edible portion is: water 79.9%, energy 268 kJ (64 kcal), protein 3.2 g, fat 0.7 g, carbohydrate 14.0 g, fibre 1.9 g, Ca 260 mg, P 52 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968).

Crassocephalum crepidioides extracts showed moderate antimutagenic activity in *Salmonella typhimurium*. The roots have been reported to contain tannin. The pyrrolizidine alkaloids jacobine and jacoline were isolated from the

aerial parts of Japanese plants; jacobine proved to be hepatotoxic. *Geotrichum*, an endophytic fungus of *Crassocephalum crepidioides*, produces dihydroisocoumarins that have shown antimalarial activity against *Plasmodium falciparum*. Essential oil obtained by hydrodistillation of the leaves consisted mainly of monoterpenes (myrcene, limonene and α-copaene).

Adulteration and substitutes *Crassocephalum crepidioides* leaves in dishes can be replaced by the leaves of *Crassocephalum rubens* (Juss. ex Jacq.) S.Moore and other *Crassocephalum* species with succulent leaves.

Description Erect, slightly succulent, annual herb up to 100(–180) cm tall; stem rather stout, soft, ribbed, branches pubescent. Leaves arranged spirally, simple to pinnately lobed or pinnatifid; stipules absent; lower leaves with short petiole, upper ones sessile; blade elliptical to obovate-elliptical in outline, 6–18 cm × 2–5.5 cm, usually lobed, irregularly serrate, base of lower leaves tapered and often long-decurrent into petiole, hairy. Inflorescence a cylindrical head 13–16 mm × 5–6 mm arranged in a terminal corymb, many-flowered; outer involucral bracts unequal, 1–4 mm long, inner ones 1–2-seriate, 8–12 mm long. Flowers bisexual, equal; corolla tubular, 9–11 mm long, yellow or orange with reddish brown top; stamens with anthers united into a tube, purple; ovary inferior, 1-celled, style 2-branched. Fruit a ribbed achene c. 2 mm long, hairy, dark purplish, crowned by white, caducous pappus hairs 9–12 mm long. Seedling with epigeal germination; hypocotyl up to 2 cm long; cotyledons broadly ovate, glabrous, shortly petiolate.

Crassocephalum crepidioides – 1, upper part of flowering and fruiting plant; 2, flower; 3, fruit with pappus; 4, fruit without pappus.
Source: PROSEA

Other botanical information In tropical Africa *Crassocephalum* comprises about 24 species, many of which have medicinal uses. The genus is placed in the tribe *Senecioneae*.

Growth and development Seedlings of ebolo appear 8–10 days after sowing. Growth of seedlings is fast. Within 40–45 days after sowing the plants are ready for the first harvest by uprooting, and harvesting for seed can start 15–17 weeks after sowing.

Ecology *Crassocephalum crepidioides* is a common weed in abandoned farm land, waste places, plantations and backyard gardens, in East Africa up to 2000 m altitude. It may be a dominant pioneer species in shifting cultivation sites that have been recently burned. The temperature requirement of ebolo is 23–30°C, and an annual rainfall of 600–1500 mm is suitable. It prefers well-drained, rich soils and tolerates wet soil, but not waterlogged conditions. It grows well under shade in plantations, e.g. cocoa or tea.

Propagation and planting Ebolo produces seeds (achenes) profusely. The weight of 1000 seeds is about 0.2 g. The seeds are difficult to process and preserve. Due to the fine silky pappus hairs covering the achenes, they are easily dispersed by wind. Removing the pappus is possible when the fruits are fully ripe, but before they spread naturally. Seedlings are normally raised in nurseries in specially prepared cool spots. Direct sowing is less common. The seeds are broadcast on the seedbed and watered twice daily. The seedlings are transplanted with a ball of earth attached and are planted on raised beds when they are 8–10 cm tall at a spacing of 30 cm × 30 cm. Transplanted crops produce vigorous plants with large leaves.

Management Ebolo grows well in soils rich in organic matter. In general application of organic manure before transplanting promotes rapid growth, production of large leaves and overall vegetative yield. As an alternative NPK fertilizers (e.g. 15–15–15) may be applied.

Weeding is required when the seedlings are young and regular irrigation is important during dry periods.

Diseases and pests Rust infection of ebolo caused by *Aecidium crassocephali* can be serious and sometimes leads to the death of the plant. A grey leaf spot (*Cercospora*) causes spots on the upper leaf surface and mould on the lower side. The green larvae of the moth *Psara pallidalis* constitute serious problems by causing the leaves to curl and by eating between the leaf veins. The black larvae of the moth *Lobesia aedopai* infest the inflorescences of young plants, feeding on the inside, especially on the receptacle. Slight leaf damage is caused by *Lagria villosa* and *Chrysolagria* sp. throughout the year. Variegated locust (*Zonocerus variegatus*) is a problem during the dry season, infesting the leaves. High population densities of green aphids may infect the apical growing point of young plants. In Nigeria the larvae of *Nyctemera perspicua* (synonym: *Deilemera perspicua*) and *Sylepta derogata* were recorded as destructive to the leaves, whereas adults and nymphs of *Aphis spiraecola* attack the leaves and stems.

Harvesting Annually considerable amounts of ebolo are harvested from the wild. In planted fields harvesting is by uprooting or repeated cuttings. The first harvest by uprooting can be expected 5–6 weeks after transplanting, and the first harvest by cutting is carried out when the plants are 20–25 cm tall. The shoots are cut at 8–10 cm above the ground to allow profuse production of new shoots. Repeated cutting is carried out at intervals of 7–14 days, depending on plant growth and vigour. This can be done for 40–50 days. Harvesting is often done in the evening or early morning to keep the leaves fresh for the market.

Yield The annual production of ebolo may reach 25–27 t/ha of leaves and shoots from repeated harvesting.

Handling after harvest The leaves wilt fast, thus repeated sprinkling with water is required to keep them fresh. The shoots can also be partially immersed in water in small buckets. Farmers often tie the shoots into small bundles before they are taken to the market.

Genetic resources There is no threat of genetic erosion of *Crassocephalum crepidioides* as it is widespread and common in disturbed habitats. There is considerable variation among landraces. There are no records of germplasm collections in Africa.

Breeding Ebolo is a vegetable of low priority to researchers in Africa. The wide genetic variation is yet to be exploited, but it will ensure rapid progress in selection and development of improved cultivars.

Prospects *Crassocephalum crepidioides* is an easy to grow vegetable, especially suited to shady localities in home gardens and tree plantations. Breeding of improved cultivars is needed, as well as research to solve the problem of seed availability that has hitherto limited cultivation. Research on its safe use as a vegetable is desirable since the presence of pyrrolizidine alkaloids, which are hepatotoxic or even carcinogenic, has been reported for Asian plants.

Major references Adams, C.D., 1963; Akinlosotu, T.A., 1983; Burkill, H.M., 1985; Denton, L. & Ojeifo, I.M., 1993; Gbile, Z.O., 1983; Hind, D.J.N., Jeffrey, C. & Scott, A.J., 1993; Lemmens, R.H.M.J., 2003; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Lowe, J. & Soladoye, M.O., 1990; van Epenhuijsen, C.W., 1974.

Other references Aletor, M.V.A. & Adeogun, O.A., 1995; Humbert, H., 1960; Jeffrey, C., 1986; Kongsaeree, P. et al., 2003; Mansfeld, R., 1986; Martin, F.W. & Ruberté, R.M., 1975; Oguntona, O., 1998; Okigbo, B.N., 1986; Rehm, S. & Espig, G., 1991; Zollo, P.H.A. et al., 2000.

Sources of illustration Lemmens, R.H.M.J., 2003.

Authors O.A. Denton

CRASSOCEPHALUM RUBENS (Juss. ex Jacq.) S.Moore

Protologue Journ. Bot. 50: 212 (1912).

Family Asteraceae (Compositae)

Chromosome number $2n = 10, 12$

Synonyms *Senecio rubens* Juss. ex Jacq. (1776), *Gynura cernua* Benth. (1849), *Crassocephalum sarcobasis* (DC.) S.Moore (1912).

Vernacular names Yoruban bologi (En). Brède yorouba (Fr).

Origin and geographic distribution *Crassocephalum rubens* is found throughout tropical Africa including the Indian Ocean islands, where it is probably introduced; it is also reported from Lesotho, South Africa and Yemen.

Uses The leaves of *Crassocephalum rubens* are commonly eaten in south-western Nigeria, less so in other humid zones of West and Central Africa. They are mucilaginous and used for

soups and sauces. In Uganda the leaves are dried, chopped and cooked with peas or beans. In Malawi the leaves and young shoots are cooked with groundnuts and tomatoes added.
Crassocephalum rubens is used medicinally as a stomachic and to treat liver complaints and colds, and externally to treat burns, sore eyes (filaria), earache, leprosy and breast cancer. In East Africa it is used as an antidote against any form of poisoning. Like garlic, the whole plant is said to repel crocodiles.

Properties The taste is variously described from 'mild' (Uganda) to 'slightly stinging' (Malawi). The smell of the leaves is characterized from 'bad' (Uganda) to 'agreeable' (West Africa). Fresh leaves contain per 100 g edible portion: water 79.9 g, energy 269 kJ (64 kcal), protein 3.2 g, fat 0.7 g, carbohydrate 14.0 g, fibre 1.0 g, Ca 260 mg, P 52 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). Traces of alkaloids have been recorded in stems and leaves and an abundance of tannins in the roots.

Botany Erect, annual herb up to 80 cm tall. Leaves arranged spirally, sessile; stipules absent; blade of lower leaves elliptical, oblanceolate or obovate, 4.5–16 cm × 2–5 cm, either not lobed, 2–4-lobed or rarely pinnately lobed; blade of upper leaves narrowly lanceolate, elliptical or ovate, not lobed or 6–8 lobed. Inflorescence a head, up to 18 heads arranged in a terminal corymb. Flowers bisexual, equal; corolla tubular, 8–10 mm long, violet, mauve or purple. Fruit a ribbed achene, up to 2.5 mm long, crowned by white pappus hairs 8–12 mm long.
In tropical Africa *Crassocephalum* comprises about 24 species, many of which have medicinal uses. The genus is placed in the tribe *Senecioneae*. Until recently *Crassocephalum rubens* and *Crassocephalum sarcobasis* were considered distinct species with considerable variation within each species. Variation has resulted in the distinction of 2 types in northern Sierra Leone. Variation in taste in Malawi means that some types are regularly eaten, others only in times of shortage. This variation is not yet fully understood.

Ecology *Crassocephalum rubens* occurs as a weed in arable land, along riversides and roadsides, mostly at higher altitudes. In Uganda it prefers sandy loams and is found up to 1800 m in areas with an annual rainfall of 1000–1600 mm.

Management Cultivation of *Crassocephalum rubens* is restricted to south-western Nigeria. It is grown in well-drained soils with a high organic matter content. It requires support and shade and is often grown among cocoa trees. Propagation is by stem cuttings 20–25 cm long, obtained from mature shoots. Removal of the flowering shoots encourages leaf production.

Genetic resources and breeding As *Crassocephalum rubens* is widespread in the tropics it is not threatened with extinction. However locally, for example in Cameroon, it has virtually disappeared through over-exploitation, and cultivation in Nigeria appears to be a response to decreased availability from the wild.

Prospects Research on the use as a vegetable would benefit from a better understanding of the variation within the species. Selection for desirable characteristics seems possible. Although widely considered a weed, it can be easily controlled, and promoting its cultivation as a vegetable or medicinal plant is not likely to aggravate the weed problems.

Major references Burkill, H.M., 1985; Hind, D.J.N., Jeffrey, C. & Scott, A.J., 1993; Humbert, H., 1963; Katende, A.B., Ssegawa, P. & Birnie, A., 1999; Kokwaro, J.O., 1993; Raji, J.A., Agboola, A.A. & Adeoye, G., 1995; Schippers, R.R., 2000.

Other references Adams, C.D., 1963; Berhaut, J., 1974; Jeffrey, C., 1986; Lemmens, R.H.M.J., 2003; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Stevels, J.M.C., 1990; Williamson, J., 1955.

Authors C.H. Bosch

CROTALARIA BREVIDENS Benth.

Protologue Hook., Lond. Journ. Bot. 2: 585 (1843).

Family Papilionaceae (Leguminosae - Papilionoideae, Fabaceae)

Chromosome number $2n = 16$

Synonyms *Crotalaria intermedia* Kotschy (1865).

Vernacular names Slenderleaf, rattlepod, rattle pea, Ethiopian rattlebox (En). Crotalaire, sonnette (Fr). Marejea (Sw).

Origin and geographic distribution *Crotalaria brevidens* occurs in the wild from northern Nigeria eastwards to Ethiopia and south to southern Tanzania. It has been introduced into the Americas. It is reported as cultivated and eaten as a vegetable in Sudan, Kenya, Uganda and Tanzania.

Uses Slenderleaf is grown for its young

Crotalaria brevidens – wild

leaves and shoots, and is used as a cooked vegetable. In Kenya and Tanzania it is known as 'marejea' or 'mitoo', in Uganda as 'alaju'. Elderly people appreciate its bitterness, whereas younger people prefer the closely related rattlepod *Crotalaria ochroleuca* G.Don. Slenderleaf is consumed boiled or fried in oil and is also used as a potherb in stews or soups. It is often boiled together with Jew's mallow (*Corchorus olitorius* L.) to reduce the bitter taste; tomatoes, onions, oil and/or milk are added.

A number of medicinal applications have been reported. In Kenya the leaves are used to cure stomach-ache, swellings and malaria. The roots are used to treat sore throat and mouth thrush. The shoots are used as livestock fodder and seeds are fed to poultry. Slenderleaf is also used as a green manure as its roots nodulate profusely and fix nitrogen. It is occasionally used for its fibre. A recent use for slenderleaf is as an agent to promote the germination of *Striga*, a parasitic plant that is a major problem for maize and millet growers. In the presence of *Crotalaria*, *Striga* germinates and it will subsequently die due to the lack of a suitable host plant. *Crotalaria* is also known to suppress *Meloidogyne* nematode populations.

Production and international trade *Crotalaria brevidens* is a vegetable of small-scale production. Since it is generally grouped together with statistics on other green vegetables, no individual data are available.

Properties The composition of leaves of *Crotalaria brevidens* and the related *Crotalaria ochroleuca* per 100 g fresh edible portion is: water 74.5 g, protein 8.8 g, Ca 222 mg, Fe 0.8 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). The composition is comparable to other dark green leaf vegetables, except that the dry matter content is higher than average. The leaves are very bitter due to the presence of toxins such as pyrrolizidine alkaloids, diterpenes and phenolic compounds.

Adulterations and substitutes In dishes slenderleaf can be replaced by *Crotalaria ochroleuca* or other *Crotalaria* species.

Description Erect much-branched annual or short-lived perennial herb up to 2 m tall; branches usually ascending, with short appressed to slightly spreading hairs. Leaves alternate, 3-foliolate; stipules absent; petiole 2–6 cm long; leaflets linear to lanceolate or elliptical, 4–10(–14) cm × 0.3–2(–3.3) cm, appressed puberulous below. Inflorescence a terminal raceme up to 50 cm long, many-flowered; bracts linear to subulate, 1–3.5 mm long. Flowers bisexual, zygomorphic, 5-merous; calyx 3–8 mm long, becoming truncate at base, deflexed against the pedicel, hairy to glabrous, lobes shorter to slightly longer than tube; corolla yellow, with ovate or elliptical standard veined reddish brown, wings about as long as keel, keel with a long beak, up to 2.5 cm long; stamens 10, all joined in a sheath open at base; ovary superior, 1-celled, style curved, stigma small. Fruit a narrowly cylindrical pod 3.5–5 cm × 0.5–1 cm, often slightly curved at the ends, pubescent, black when dry, many-seeded. Seeds oblique-cordiform, up to 3 mm long, smooth, pale yellow, turning orange to dark red.

Other botanical information *Crotalaria* comprises about 600 species and occurs throughout the tropics. Africa is by far richest with approximately 500 species. Besides the cultivated *Crotalaria brevidens*, *Crotalaria ochroleuca* and *Crotalaria natalitia* Meisn., several wild *Crotalaria* species are occasionally collected as potherbs, e.g. *Crotalaria anthyllopsis* Welw. ex Baker, *Crotalaria cephalotes* Steud. ex A.Rich., *Crotalaria cleomifolia* Welw. ex Baker, *Crotalaria florida* Welw. ex Baker and *Crotalaria senegalensis* (Pers.) Bacle ex DC.

Crotalaria brevidens is closely related to *Crotalaria ochroleuca* and information cannot always be attributed to either one of them with certainty. *Crotalaria brevidens* can best be distinguished by the colour of the flower (usually bright yellow vs. pale yellow or creamish in *Crotalaria ochroleuca*), the calyx (often puberulous vs. glabrous), and the fruit diameter (0.5–

1 cm vs. (1–)1.5–2 cm).
Four varieties of *Crotalaria brevidens* have been distinguished. Var. *brevidens*, with glabrous calyx 3.5–5(–7) mm long, occurs predominantly in the northern part of the range. Var. *intermedia* (Kotschy) Polhill, with puberulous calyx 5–8 mm long, is the most widespread. Var. *parviflora* (Baker f.) Polhill, with a smaller flower, is restricted to the Kenya highlands, whereas var. *dorumaensis* (R.Wilczek) Polhill is of doubtful status and only known from DR Congo.

Growth and development The seed germinates in 3–4 days. Initially the plant grows slowly and is ready for harvesting 8 weeks after sowing. Harvesting may continue for 4 months.

Ecology Slenderleaf occurs in open and wooded grassland and is occasionally found in seasonal swamps and on termitaries, at 500–2700 m altitude.

Propagation and planting The 1000-seed weight is about 5 g. Slenderleaf is sown broadcast or in rows of 30 cm apart and then thinned 6 weeks after sowing to a spacing of 15–20 cm × 15–20 cm.

Management Slenderleaf responds well to farmyard manure but less well to artificial fertilizers. Application of 20 t/ha of cattle manure is recommended.

Diseases and pests *Crotalaria brevidens* does not suffer much from diseases and even less from pests. Under wet conditions the whole crop may be destroyed by a blight just before it starts flowering. Aphids and thrips can be observed, but are rarely a serious menace. During fruit development, pod borers may enter and interfere with seed development. The holes in the pods will allow rain to enter and destroy the seeds further through rot.

Harvesting Slenderleaf is uprooted just before flowering when the stems are about 40 cm tall and 8 weeks old. Alternatively, farmers use the thinnings as a first harvest after about 6 weeks and use a ratoon system from there onwards. The ratoon system involves first plucking the main shoot at the 8-week stage and subsequent harvesting of the new side shoots. The main shoot is cut 10–15 cm above the ground, with at least 3 leaves left. New side shoots can be picked again after 2 weeks and harvesting can take place up to 15 times if there is enough rain and application of nitrogen.

Yield The yield for a once-over harvest is about 10 t/ha (1 kg/m²); for repeated harvests the yield is much higher.

Handling after harvest Fresh leaves and young shoots are very perishable and do not keep well. At 20–30°C they will last for 1 day; for longer storage they should be kept below 20°C. To reduce deterioration the shoots are tied in bundles, which are regularly sprinkled with water. The leaves are often dried to be sold during the dry season. Drying in the sun takes 3–4 days during the dry season and 6–7 days during the rainy season.

Genetic resources *Crotalaria brevidens* is not endangered because it is widely distributed in the wild and several local types are cultivated. It has been included in the Traditional African Vegetables Mandate List for conservation in the SADC region. The Kew Millennium Seed Bank Project has targeted traditional vegetables and established sizeable collections that are kept in both Nairobi and the United Kingdom.

Prospects Slenderleaf is a popular traditional vegetable in some parts of East Africa, with good nutritional properties. Research priorities are breeding and cultivation technology.

Major references Chweya, J.A., 1985; Chweya, J.A., 1997; Gillett, J.B. et al., 1971; Maundu, P.M., Ngugi, G.W. & Kabuye, C.H.S., 1999; Olembo, N.K., Fedha, S.S. & Ngaira, E.S., 1995; Polhill, R.M., 1982; Schippers, R.R., 2000; Sosef, M.S.M. & van der Maesen, L.J.G., 1997; Uiso, F.C. & Johns, T., 1996a; Uiso, F.C. & Johns, T., 1996b.

Other references Cotias de Oliveira, A.L.P. & de Aguiar Perecin, M.L.R., 1999; Imbamba, S.K. & Tieszen, L.L., 1977; Leung, W.-T.W., Busson, F. & Jardin, C., 1968.

Authors M.O. Abukutsa-Onyango

CROTALARIA NATALITIA Meisn.

Protologue London Journ. Bot. 2: 67 (1843).
Family Papilionaceae (Leguminosae - Papilionoideae, Fabaceae)
Chromosome number $2n = 16$
Vernacular names Rattlepod (En). Marejea (Sw).

Origin and geographic distribution *Crotalaria natalitia* occurs widely in East and southern Africa. In Central Africa it is restricted to Burundi and the extreme east of DR Congo. It is also found in Yemen.

Uses The tender leaves of *Crotalaria natalitia* are used as a vegetable in Tanzania and Malawi. In Malawi fresh leaves and flowers are

cooked with potash, giving a mucilaginous product. In Tanzania the fresh leaves are used, as well as pounded and dried leaves. People add groundnuts or coconut milk to make the dish more palatable.
In Tanzania *Crotalaria natalitia* is also used as an ornamental and as a green manure. The bark from fresh roots is chewed, and the juice swallowed as a treatment for boils. After several days the boils ripen, can be cut and squeezed out.

Botany Perennial herb or small shrub up to 2.5 m tall; branches usually ascending, with short appressed to slightly spreading hairs. Leaves mostly in tufts, 3-foliolate; stipules asymmetrical, 0.5–1.5 cm long; petiole slightly shorter than leaflets; leaflets oblanceolate-linear to oblanceolate-elliptical, (1.5–)2–4.5 cm × 0.4–1.5 cm, appressed pubescent below. Inflorescence a terminal raceme up to 22 cm long, few- to many-flowered; bracts linear to elliptical-caudate, 2.5–6 mm long. Flowers bisexual, zygomorphic, 5-merous; calyx 6–10 mm long; corolla yellow, with ovate or elliptical standard tinged reddish brown, wings longer than keel, keel with a short incurved beak, up to 1.5 cm long; stamens 10, all joined in a sheath open at base. Fruit a broadly cylindrical, inflated pod 3.5–4.5 cm × 1–1.5 cm, glabrous, many-seeded. Seeds oblong-reniform, up to 4 mm long, smooth, dark brown.
Crotalaria comprises about 600 species and occurs throughout the tropics. Africa is by far richest with approximately 500 species. The more important leaf vegetables in the genus are *Crotalaria brevidens* Benth. and *Crotalaria ochroleuca* G.Don. *Crotalaria* spp. are often difficult to distinguish and may have been confused in the literature.

Ecology *Crotalaria natalitia* occurs in the plateau regions of East Africa and Angola in a variety of moderately open habitats such as grassland, forest edges and roadsides, up to 3000 m altitude. It descends to sea-level along the east coast of Africa.

Management In Tanzania *Crotalaria natalitia* is traded on local markets.

Genetic resources and breeding *Crotalaria natalitia* is not threatened by genetic erosion because it is widely distributed and fairly common.

Prospects *Crotalaria natalitia* is a vegetable of local importance, and will likely remain so.

Major references Burkill, H.M., 1995; Polhill, R.M., 1982; Ruffo, C.K., Birnie, A. & Tengnäs, B., 2002; Williamson, J., 1955.

Other references Kokwaro, J.O., 1993.

Authors C.H. Bosch

CROTALARIA OCHROLEUCA G.Don

Protologue Gen. hist. 2: 138 (1832).

Family Papilionaceae (Leguminosae - Papilionoideae, Fabaceae)

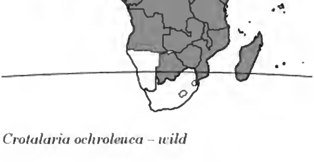
Chromosome number $2n = 16$

Synonyms *Crotalaria cannabina* Schweinf. ex Baker f. (1914), *Crotalaria intermedia* auct. non Kotschy.

Vernacular names Rattlepod, rattlebox (En). Crotalaire, sonnette (Fr). Marejea (Sw).

Origin and geographic distribution *Crotalaria ochroleuca* is found almost throughout tropical Africa except the north-eastern and most southern parts and most islands of the Indian Ocean. Outside Africa, it has become naturalized in Brazil, the United States (Florida), Australia, New Guinea and China. It is used as a wild or cultivated vegetable in several African countries: Senegal, Nigeria, Cameroon, Congo, DR Congo, southern Sudan, western Kenya, Uganda and north-western Tanzania.

Uses Rattlepod is used as a leafy vegetable in Kenya and Tanzania, where it is known as 'marejea' or 'mitoo' and in Uganda, where it is called 'alaju'. The young shoots are harvested, but towards the end of the season also individual leaves are collected. These are chopped, boiled and eaten with the staple food maize, beans or sorghum. In Uganda people may add sesame (*Sesamum radiatum* Schumach. & Thonn.) or groundnut paste. Due to its slightly



Crotalaria ochroleuca – wild

bitter taste, most people cook it with other vegetables such as amaranth, cowpea or pumpkin leaves, or alternatively with milk. Some tribes also consume young pods and flowers in soups, but people are careful about the latter use since drowsiness occurs when flowers are eaten in quantity. Dried flowers retain their special flavour a long time and are used as a condiment for soups.
Rattlepod is used as livestock fodder and seeds are fed to poultry. Care should be taken not to use too much because the seeds contain slow-acting pyrrolizidine alkaloids that may cause damage to lungs and liver. *Crotalaria ochroleuca* has the capacity to fix atmospheric nitrogen by bacteria in the root nodules. Like the common sunnhemp (*Crotalaria juncea* L.) it is used as a green manure in crops or fallows, but this use is rare. In Sudan its fibre is used to make nets. A recent use for rattlepod is as an agent to promote the germination of *Striga*, a parasitic plant that is a major concern for maize and millet growers in Africa. In the presence of *Crotalaria*, *Striga* germinates and it will subsequently die due to the lack of a suitable host plant. *Crotalaria ochroleuca* is also known to suppress *Meloidogyne* root-knot nematode populations and is locally used by East African farmers either in crop rotations or as a companion crop with nematode-susceptible vegetables such as tomatoes. The leaves are used by the Tiv people in Nigeria as a treatment for yellow fever. In Sierra Leone they are applied to sore feet. Oil extracted from the seeds is insect repellent.

Production and international trade Few statistical data are available. In Kenya and Uganda the cultivated area is approximately 3000–5000 ha, mainly as a home garden crop. All trade is through local or regional markets and international trade is limited to local cross-border trade.

Properties The composition of *Crotalaria ochroleuca* per 100 g edible portion is: water 74.5 g, protein 8.8 g, Ca 222 mg, Fe 0.8 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). The composition is comparable to other dark green leaf vegetables, except that the dry matter content is higher than average. Analyses in Kenya gave per 100 g fresh weight: protein 4.2–4.9 g, Ca 270 mg, Fe 4 mg, β-carotene 2.9–8.7 mg, ascorbic acid 115–129 mg (Schippers, R.R., 2000). The bitterness in the leaves is caused by the presence of toxins such as pyrrolizidine alkaloids, diterpenes and phenolic compounds.

Adulterations and substitutes *Crotalaria ochroleuca* can be replaced in dishes by the more bitter tasting *Crotalaria brevidens* Benth., which is especially liked by elderly people, or other *Crotalaria* species. As mulch plant and green manure, it can be replaced by *Crotalaria juncea*.

Description Erect much-branched annual or short-lived perennial herb up to 2.5 m tall; branches ascending, with short appressed hairs. Leaves alternate, 3-foliolate; stipules absent; petiole 1–6.5 cm long; leaflets linear to lanceolate or elliptical-lanceolate, 5–13(–18) cm × 0.5–3 cm, appressed puberulous below. Inflorescence a terminal raceme up to 50 cm long, many-flowered; bracts linear to subulate, 2–4 mm long. Flowers bisexual, zygomorphic, 5-merous; calyx 6–8 mm long, becoming truncate at base, deflexed against the pedicel, glabrous, lobes usually shorter than tube; corolla creamish or pale yellow, with ovate standard veined reddish or maroon, wings usually shorter than keel, keel with a long beak, up to 2(–2.3) cm long; stamens 10, all joined in a sheath open at base; ovary superior, 1-celled, style curved, stigma small. Fruit a broadly cylindrical pod

Crotalaria ochroleuca – 1, flowering and fruiting twig; 2, flower; 3, seed.
Redrawn and adapted by Achmad Satiri Nurhaman

(4–)5–7 cm × (1–)1.5–2 cm, appressed puberulous, black when dry, many-seeded. Seeds oblique-cordiform, c. 3.5 mm long, smooth, pale yellow to orange.

Other botanical information *Crotalaria* comprises about 600 species and occurs throughout the tropics. Africa is by far richest with approximately 500 species. Besides the cultivated *Crotalaria ochroleuca*, *Crotalaria brevidens* and *Crotalaria natalitia* Meisn., several wild *Crotalaria* species are occasionally collected as potherbs, e.g. *Crotalaria anthyllopsis* Welw. ex Baker, *Crotalaria cephalotes* Steud. ex A.Rich., *Crotalaria cleomifolia* Welw. ex Baker, *Crotalaria florida* Welw. ex Baker and *Crotalaria senegalensis* (Pers.) Bacle ex DC.

Crotalaria ochroleuca is closely related to *Crotalaria brevidens* and information cannot always be attributed to either one of them with certainty. *Crotalaria ochroleuca* can best be distinguished by the colour of the flower (pale yellow or creamish vs. usually bright yellow in *Crotalaria brevidens*), the calyx (glabrous vs. often puberulous), and the fruit diameter ((1–)1.5–2 cm vs. 0.5–1 cm).

Growth and development The seed germinates in 3–4 days. Early growth is slow and it may take about 8 weeks until the first harvest. The plant dies after about 6 months. *Crotalaria ochroleuca* forms root nodules with slow-growing *Bradyrhizobium* bacteria.

Ecology *Crotalaria ochroleuca* is mainly found in damp grassland, especially in floodplains, depressions and along edges of swamps and rivers, but also in deciduous bushland, roadsides and fields. It grows in open localities with adequate sunshine at 300–2000 m altitude. It is favoured by warm conditions, and after the crop is well established and has formed long taproots and long lateral roots, it can tolerate rather dry conditions. In East Africa *Crotalaria ochroleuca* has become quite rare in the wild.

Propagation and planting The 1000-seed weight is about 5 g. Propagation is by seed, which is sown broadcast or in rows 30 cm apart at a seed rate of 4–5 kg/ha. Thinning is done 6–8 weeks after sowing to a spacing of 10–20 cm × 10–20 cm, depending on both soil fertility and moisture level. Under dry conditions, the spacing may be up to 30 cm × 30 cm. The thinned material can be used as the first harvest. When grown for a single harvest, 4–5 crops per year can be grown, but most farmers prefer to rotate rattlepod with other crops. Rattlepod as a vegetable can be grown as a sole crop or be intercropped with finger millet, maize, kenaf and a range of other crops that benefit from the nitrogen-fixing capacity and suppression of the nematode population. As a mulch crop for bananas, coffee, kenaf, maize or sweet potato, it is sown in rows in between these main crops. When grown as a fallow crop or for green manure, seed is broadcast.

Management Despite its nitrogen-fixing capacity, rattlepod responds well to nitrogenous fertilizers. Application of farmyard manure at a rate of 20 t/ha is recommended. The crop responds well to irrigation when rainfall is inadequate, especially at the early stages.

Diseases and pests Few diseases are a threat to rattlepod. Fusarium wilt and to a limited extent also a mosaic-like virus occur. Under very humid conditions, the whole crop may be destroyed by a disease just before flowering. The causal agent of this disease has not yet been identified; it is probably a form of downy mildew. Aphids and thrips are often observed, but rarely cause serious damage. During fruit development, pod borers may enter and interfere with seed development. The most important pod borers are *Helicoverpa armigera* and *Maruca vitrata*. The holes in the pods will allow rain to enter and destroy the seeds further through rot. *Crotalaria* acts as a host plant for these pod borers, which can be a serious pest of beans, tomatoes, maize and cotton. *Cuscuta suaveolens* Ser., a parasitic plant that forms thread-like masses of leafless branches, may choke the crop. This South American parasitic plant is spreading in the West Nile region of both Kenya and Uganda, where rattlepod is cultivated.

Harvesting Rattlepod as a vegetable can be harvested once-over by uprooting just before flowering when the stems are about 40 cm tall and 8 weeks old. Most farmers use this method when growing rattlepod as a catch crop between other crops. Alternatively, farmers use the thinnings as a first harvest after about 6 weeks and use a ratoon system from there onwards. The ratoon system involves first plucking the main shoot at the 8-week stage and subsequent harvesting of the new side shoots. The main shoot is cut 10–15 cm above the ground, with at least 3 leaves left. New side shoots can be picked again after 2 weeks and harvesting can take place up to 15 times if there is enough rain and application of nitrogen. Towards the dry season, no further shoots develop and people may pluck the remaining

leaves before abandoning the crop.
If sown as a green manure, the young crop is incorporated in the soil. For mulch, the plants are uprooted or cut at soil level and placed between the crop rows.

Yield The yield for a once-over harvest is about 10 t/ha (1 kg/m²). A green manure crop yields about 20 t/ha fresh organic matter.

Handling after harvest Shoots are tied in bundles to be sold fresh at the market. The product is very perishable, and is therefore expensive in cities far from the production areas. Sprinkling the leaves with water may be detrimental since they may rot. The best way to retain their quality is by cooling the product wherever feasible. Bundles should be loosely packed in bags, not tightly like most other crops. In northern Uganda, people may get a substantial income from the dried produce. Sun drying takes 3–4 days during the dry season and 6–7 days during the rainy season. The dried leaves can be stored for up to 6 months. Flowers and young pods are plucked and dried separately for use as a condiment.

Genetic resources *Crotalaria ochroleuca* is not threatened as it occurs wild virtually throughout tropical Africa.

Breeding So far rattlepod has not been paid much attention by seed companies or research stations and improved cultivars have not been released.

Prospects Rattlepod is a promising dual-purpose crop. Besides a high nutritional value, it has great advantages such as its repulsiveness to nematodes and its nitrogen-fixing abilities. There is some concern about the chemical compounds present in this crop, making it a health hazard when consumed regularly. The toxic compounds can possibly be eliminated by breeding. Rattlepod is increasingly in demand as a traditional vegetable at the city markets.

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Sources of illustration Polhill, R.M., 1982.

Authors R.R. Schippers

CUCUMEROPSIS MANNII Naudin

Protologue Ann. Sci. Nat., sér. 5,5: 30 (1866).

Family Cucurbitaceae

Chromosome number $2n = 22$

Synonyms *Cucumeropsis edulis* (Hook.f.) Cogn. (1881).

Vernacular names Egusi-itoo, white seed melon, dark egusi (En). Egousi-itoo, égousi, gousi (Fr). Lipupu (Po).

Origin and geographic distribution Egusi-itoo occurs wild from Guinea Bissau east to southern Sudan and Uganda, and south to Angola. It is mostly cultivated in West Africa, especially in Nigeria, but occasionally also elsewhere, e.g. in Côte d'Ivoire, Cameroon and the Central African Republic. Egusi-itoo used to be very important as a seed vegetable in West Africa and parts of Central Africa at a time when there was plenty of forest to practise shifting cultivation. Now it is in strong decline, being replaced by egusi melon (*Citrullus lanatus* (Thunb.) Matsum. & Nakai).

Uses Egusi-itoo is mainly grown for its oily seed. The seeds are prepared for consumption by parching and pounding to free the kernels of the seedcoat. The kernels are milled into a whitish paste which is used in soups and stews. The seeds (including seedcoat) are also roasted and served as a snack. They resemble groundnut in flavour.
An expensive semi-drying oil is extracted from the kernel, whereas the residue is fed to animals or used in the preparation of local snacks. The oil is suitable for cooking, soap making and, less commonly, illumination. It can readily be refined into superior products for table

Cucumeropsis mannii – wild and planted

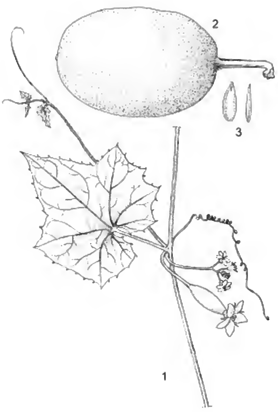
use. It is of better quality and higher value than cottonseed oil. The flesh of the fruit, though edible, is not commonly eaten.
In Ghana the fruit juice mixed with other ingredients is applied to the navel of newborn babies to accelerate the healing process until the cord-relics drop off. Macerated leaves are used in Gabon for purging constipated suckling babies. In Sierra Leone cattle boys traditionally use the dried fruit-shell of an egusi-itoo type with small elongated fruits as a warning horn.

Production and international trade Egusi-itoo is regarded as the original indigenous egusi melon in West and Central Africa and the seed can be found in most markets in the region. In Nigeria the demand for the seeds, particularly in the towns, led to large-scale planting. Although its production is declining, egusi-itoo still is a common article in the markets. The trade is mostly local. Export occurs from Côte d'Ivoire to Nigeria, but the quantities involved are not reported.

Properties The nutritional composition of egusi-itoo seed per 100 g is: water 8.3 g, energy 2282 kJ (545 kcal), protein 26.2 g, fat 47.3 g, carbohydrate 14.2 g, fibre 4.0 g, Ca 86 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). The seeds are rich in niacin (14.3 mg/100 g). The oil content of the kernel is 44% by weight. A sample of egusi-itoo seed oil from Côte d'Ivoire consisted of linoleic acid 64.9%, oleic acid 12.4%, stearic acid 11.8% and palmitic acid 10.9%.

Adulteration and substitutes Egusi-itoo is replaced in many regions by egusi melon (*Citrullus lanatus*).

Description Monoecious scandent herb up to 5(–10) m long, climbing by simple tendrils; stem angular, sparsely hairy. Leaves alternate, simple; stipules absent; petiole 2–12(–15) cm long, initially hairy but glabrescent; blade broadly ovate in outline, (6–)9–18(–21) cm × 7–15(–21) cm, deeply cordate at base, pentagonal to palmately 3–5-lobed with triangular to ovate lobes, margin sinuate-toothed, sparsely hairy on the veins, scabrid-punctate, palmately veined. Flowers unisexual, regular, 5-merous, yellow; calyx campanulate, lobes up to 6 mm × 1.5 mm; corolla with lobes shortly united at base; male flowers in an axillary raceme, often umbel-like, pedicel up to 2 cm long, corolla lobes up to 7 mm × 5 mm, with 3 free stamens almost lacking filaments; female flowers solitary in leaf axils, pedicel up to 5 cm long, corolla lobes up to 11 mm × 6 mm, with inferior, fusiform, 1-celled ovary, style columnar, stigmas 3, 2-lobed. Fruit an ellipsoid to obovoid berry 17–25 cm × 8–18 cm, green to pale yellow or creamy white, mottled, glossy, flesh white, many-seeded. Seeds obovate, flattened, 1–2 cm × 0.5–1 cm, smooth, white. Seedling with epigeal germination; cotyledons leafy, elliptical.



Cucumeropsis mannii – 1, part of flowering stem; 2, fruit; 3, seeds.
Redrawn and adapted by Iskak Syamsudin

Other botanical information *Cucumeropsis* comprises a single species. It belongs to the tribe *Melothrieae*, together with *Cucumis*.

Growth and development In West Africa egusi-itoo is usually planted in March–May at the start of the rainy season and harvested 6–8 months later (September–December). The crop requires support and is commonly found at the edge of gardens, climbing into shrubs or trees. When grown in shifting cultivation, debris left after burning serves as support. Egusi-itoo does not do well in the open or on flat land.

Ecology Egusi-itoo occurs in forest, often at the margin or in openings, but also in swamp forest, more humid savanna and abandoned fields, up to 1150 m altitude.

Propagation and planting At the beginning of the rainy season 3–4 seeds per hole are

sown. The 1000-seed weight is (150–)220–250 g. Seedlings usually appear within 6–8 days. Egusi-itoo is often grown between other crops, growing on stakes along with yam or supported by a strong trellis of at least 1 m tall.

Management Egusi-itoo is still mainly collected from wild stands, which are often retained when clearing fields. In cultivation it requires a soil rich in manure or partially decomposed organic matter. Application of N and K fertilizer can increase yields considerably, but P fertilizer has shown little effect.

Diseases and pests In Nigeria a severe damping-off disease caused by *Macrophomina phaseolina* has been reported. The fruits are sometimes attacked by the fruit fly *Dacus punctifrons*. The larvae develop in the fruit and eventually cause rot. Fruit flies attack fruits at every stage of development and can severely affect production. The pupae are found in the soil and it is therefore advised not to plant in the same field the following year. The aphid-like flea hopper *Halticus tibialis* may suck sap from the leaves; young leaves become wrinkled, older ones become swollen around the sucking holes and later die. Several other pests attacking cucurbits are also found on egusi-itoo.

Seed of egusi-itoo stored in open jars may be seriously damaged by beetles within a few weeks of storage; these have been identified as *Triboleum castaneum* and *Lasioderma serricorne*, and are also found in dried okra (*Abelmoschus* spp.) and roselle (*Hibiscus sabdariffa* L.) fruits.

Harvesting Fruits are collected when the stems have dried and fruits have changed colour from green to creamy white or yellow.

Yield Under extensive management, where egusi-itoo is planted around remaining trunks of trees, seed yield is about 300 kg/ha. In more intensive cropping systems, where land has been cleared and burnt before cultivation, it may reach 900 kg/ha. A plant usually produces 2–5 fruits; each fruit weighs 0.8–1.8 kg and contains 90–400 seeds (up to 100 g).

Handling after harvest After collection, fruits are cracked or split open; they are then placed in a heap or pit and are left for 14–20 days to let the fruit pulp rot. During this period a strong pungent smell is produced and this explains why seed extraction takes place at a distance from the homestead. Then the seeds are removed and thoroughly washed to remove thick mucilage covering them; next they are covered with sand or ash to prevent sticking, which would make hulling difficult. The seeds are dried to about 10% moisture content before packing. Packaging must be thorough and packs must be stored away from moisture, as seeds otherwise may germinate. Hulling is facilitated by heating to 60°C. The weight of decorticated seed is about 60% of the whole dry seed. The kernels are milled and used as a vegetable or for producing vegetable oil for domestic use. Processing the seed of egusi-itoo is time consuming and labour intensive; this is one of the reasons why it has been partly replaced by egusi melon.

Genetic resources Germplasm of several *Cucurbitaceae* species used as seed vegetable, including *Cucumeropsis mannii*, is being maintained at the genebank of the National Centre for Genetic Resources and Biodiversity (NACGRAB), Ibadan, Nigeria.

Prospects Unless the seed yield of egusi-itoo can be increased and its crop management and seed processing can be simplified, it seems likely that its replacement by cultivars of egusi melon will continue, although specialty markets may develop.

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Sources of illustration Jeffrey, C., 1967; Stevels, J.M.C., 1990.

Authors J.K. Egunjobi & A.A. Adebisi

CUCUMIS AFRICANUS L.f.

Protologue Suppl. pl.: 423 (1781).

Family Cucurbitaceae

Chromosome number $2n = 24$

Synonyms *Cucumis hookeri* Naudin (1870).

Origin and geographic distribution *Cucumis africanus* occurs in Angola, Namibia, Botswana and South Africa. It is also found in Madagascar, where it probably has been introduced.

Uses The leaves of *Cucumis africanus* are eaten as a cooked vegetable by many tribes in

its area of origin. Non-bitter fruits serve as a source of water and are eaten as a vegetable. In Madagascar only the fruits are eaten.

Properties The leaves contain per 100 g: water 92.2 g, protein 1.3 g, fat 0.3 g, carbohydrate 3.4 g, fibre 1.2 g, Ca 216 mg, Mg 175 mg, P 11 mg, Fe 12 mg, thiamin 0.02 mg, riboflavin 0.11 mg, niacin 0.34 mg and ascorbic acid 81 mg. The fruits contain per 100 g: water 88.2 g, protein 2.8 g, fat 1.6 g, carbohydrate 3.3 g, fibre 2.9 g, Ca 13 mg, Mg 29 mg, P 20 mg, Fe 1.1 mg, thiamin 0.2 mg, riboflavin 0.03 mg, niacin 0.84 mg and ascorbic acid 13 mg (Arnold, T.H., Wells, M.J. & Wehmeyer, A.S., 1985).

Plants with non-bitter, large and oblong fruits occur wild in Angola, Namibia and South Africa. The smaller, ellipsoid fruits found in other *Cucumis africanus* types are bitter, possibly poisonous and unsuitable for consumption. A third type, intermediate in taste and shape, seems to exist as well.

The fruit of *Cucumis africanus* contains considerable amounts of cucurbitacin A, B and D and traces of cucurbitacin G and H. Cucurbitacins, which are known from many *Cucurbitaceae* and various other plant species, exhibit cytotoxicity (including antitumour activity), anti-inflammatory and analgesic activities.

Botany Annual, monoecious, prostrate or scandent herb, sometimes with woody, thickened roots, stems up to 1 m long; tendrils simple. Leaves alternate, simple; stipules absent; petiole 1–1.5 cm long; blade ovate, deeply palmately (3–)5-lobed, 1.6–8.2 cm × 1.8–7 cm, cordate at base, lobes elliptical, broadly elliptical to ovate-elliptical. Flowers unisexual, regular, 5-merous; receptacle 3–5 mm long; sepals 1.5–3 mm long; petals bright yellow, 5–11 mm long; male flowers 1–5 together in small fascicles, with pedicel up to 1 cm long, stamens 3; female flowers solitary, with pedicel 1–4 cm long, ovary inferior, densely softly spiny. Fruit an ellipsoid to oblong-ellipsoid berry 3–9 cm × 2–4.5 cm, when ripe strongly longitudinally striped pale greenish-white and purplish-brown, with spines 3–6 mm long; fruit stalk 2–4.5 cm long, slender, not expanded upwards. Seeds ellipsoid, compressed, 4–7 mm × 2–3.8 mm × 1–1.2 mm.

The genus *Cucumis* includes about 30 species, 4 of which are economically important: cucumber (*Cucumis sativus* L.), melon and snake cucumber (*Cucumis melo* L.), West Indian gherkin (*Cucumis anguria* L.) and horned melon (*Cucumis metuliferus* Naudin). *Cucumis africanus* is placed in the 'anguria' group of the subgenus *Melo*. Literature, especially the older literature, should be interpreted with caution as other *Cucumis* species have often been misidentified as *Cucumis africanus*.

In Madagascar *Cucumis africanus* flowers from January to June.

Ecology *Cucumis africanus* occurs in dry bushland. In Madagascar it is restricted to areas close to habitation.

Management Leaves and fruits are collected from the wild. In Madagascar the fruits are collected from semi-wild plants.

Genetic resources and breeding *Cucumis africanus* is not uncommon in its area of origin and hence is not threatened with genetic erosion or extinction. *Cucumis africanus* germplasm is stored in the United States, United Kingdom, the Czech Republic and Spain.

Within the 'anguria' group of about 16 spiny-fruited *Cucumis* species to which *Cucumis anguria* belongs as well, there seem to be no major barriers to gene exchange. Several interspecific crosses have been made in this group. An intermediate response to downy mildew (*Pseudoperonospora cubensis*) has been reported for *Cucumis africanus*.

Prospects In southern Africa *Cucumis africanus* is considered to have potential for domestication. The variation within the species will allow successful breeding and selection. Breeders' interest will focus on disease resistance within the scope of gene transfer to the economically important *Cucumis* species.

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Authors C.H. Bosch

CUCUMIS ANGURIA L.

Protologue Sp. pl. 2: 1011 (1753).

Family Cucurbitaceae

Chromosome number $2n = 24$

Synonyms *Cucumis longipes* Hook.f. (1871).

Vernacular names West Indian gherkin, bur cucumber, gooseberry gourd (En). Concombre antillais, cornichon des Antilles, ti-concombre, macissis (Fr). Pepino das Antilhas, cornichão das Antillas, machiche, maxixé (Po).

Cucumis anguria – wild and planted

Origin and geographic distribution *Cucumis anguria* is of African origin and it occurs wild in East and southern Africa. It has bitter fruits, but occasionally non-bitter types occur. Seeds were taken to the Americas with the slave trade, where the cultivated West Indian gherkin was developed. This edible, non-bitter type spread through the Caribbean, parts of Latin America and the southern United States. It can now be found in a semi-wild state as an escape from cultivation, and in some cases it appears to be an element of the indigenous flora. It is an invasive weed in parts of North America and in Australia, and a serious weed in peanut fields of the southern United States. The non-bitter edible form was reintroduced into Africa (e.g. Cape Verde, Senegal, Sierra Leone, DR Congo, Réunion, Madagascar, South Africa), where it is grown for its fruits. In Madagascar *Cucumis anguria* is probably not originally wild, but naturalized because it is localized around human habitations.

Uses The leaves of bitter forms of *Cucumis anguria* are cooked and eaten, in the same manner as pumpkin leaves (*Cucurbita* spp.). In Ruwangwe, Zimbabwe, it is known as 'mubvororo' and used to prepare a special dish for the father of the household. In Namibia, it is one of a range of edible wild greens, which are dried into cakes and stored for use during the dry season. Elsewhere in Africa the non-bitter form is cultivated for its fruits. It is recorded near Thiès (Senegal), where the immature fruits are pickled green. In South Africa the fruits are eaten both fresh and dried.

In the New World, West Indian gherkin refers to the cultivated non-bitter form, a favourite pickle since the 17th century and sometimes eaten fresh. Fruits are also relatively common as a table vegetable and they are used in soups and stews. In Brazil, the mature fruits are cooked as the main ingredient of a traditional soup called 'maxixada'. Immature fruit are used as fresh cucumbers.

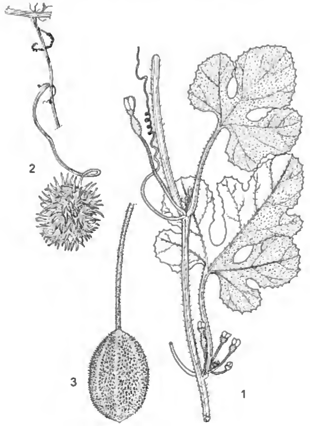
Bitter forms of *Cucumis anguria* are sometimes used in Zimbabwe as a natural pesticide in stored crops. The juice of the fruit is reportedly used as an antifeedant in granaries. In Matabeleland (Zimbabwe) the fruit is used as a lure in rock and stick traps. Medicinal uses are reported from Tanzania where an enema of the wild plant is used to treat stomach pain. In Zimbabwe traditional medical practitioners consider the bitter fruit as poisonous and the juice of the fruit is used to treat septic wounds in livestock. In America, medicinal uses are varied, including root decoctions as a remedy for stomach trouble in Mexico, and to reduce oedema in Cuba. The fruit is eaten to treat jaundice in Curaçao, and leaf juice preparations are applied to freckles in Cuba. Kidney problems are treated with a decoction in Colombia, where it is believed that the fruits eaten raw dissolve kidney stones. The fruit is applied to haemorrhoids in Cuba, and the leaves after being steeped in vinegar are used against ringworm.

Production and international trade *Cucumis anguria* as a leafy vegetable is collected from the wild or grown on a small scale in southern Africa, but no data on its production or trade are available. The cultivation of *Cucumis anguria* for non-bitter young fruits is also practised on a small scale only. In the New World, where it is always cultivated for its immature fruits, it is also of minor importance and in statistics is combined with pickling cucumber (*Cucumis sativus* L.).

Properties The nutrient composition of the fresh fruit of West Indian gherkin per 100 g edible portion is: water 93 g, energy 71 kJ (17 kcal), protein 1.4 g, fat 0.1–0.5 g, total sugar 1.9–2.5 g, starch 0.3–0.4 g, Ca 25–27 mg, P 33–34 mg, Fe 0.6 mg, vitamin A 200–325 IU, thiamin 0.05–0.15 mg, riboflavin 0.40 mg, niacin 0.3–0.5 mg, ascorbic acid 48–54 mg (Whitaker & Davis, 1962). No data are reported on the composition of the leaves, but this is probably similar to other East African dark green leafy vegetables. The seed oil of fruits of the wild bitter form is composed of palmitic, stearic, oleic, linoleic and linolenic acids.

Many cucurbits have both bitter and non-bitter forms within the same species. In the bitter forms of *Cucumis anguria*, the bitterness increases considerably as the fruit ripens. The bitter principles, known as cucurbitacins, are tetracyclic triterpenoids. Cucurbitacins are amongst the most bitter substances known and are extremely toxic to mammals. In *Cucumis anguria* the main bitter principle is cucurbitacin B ($C_{32}H_{48}O_8$) with a much smaller amount of cucurbitacin D ($C_{30}H_{46}O_7$) and traces of cucurbitacins G and H. Toxicity studies showed the juice of the fruits to be highly toxic to rats (LD_{50} 1.6 mg/kg). The toxicity is reported to be reduced more than 100-fold if the juice is first boiled. Studies on the larvicidal activity of aqueous, ethanolic and citric acid extracts from *Cucumis anguria* on *Aedes aegypti*, the yellow fever and dengue fever mosquito, showed that concentrations of 0.5 mg/ml after 24-hour exposure caused larval mortalities of up to 40%.

Description Annual monoecious herb with trailing or scandent stems, having solitary, simple, setose tendrils 3–6 cm long; stems grooved, with bristle-like hairs. Leaves alternate, simple; stipules absent; petiole (2–)6–13 cm long, hispid to setose; blade broadly ovate in outline, 3–12 cm × 2–12 cm, shallowly to deeply palmately 3–5(–7)-lobed, with punctate to hispidulous hairs on both surfaces. Flowers unisexual, regular, 5-merous; sepals narrowly triangular, 1–3 mm long; petals united at base, 4–8 mm long, yellow; male flowers in 2–10-flowered fascicles, with pedicel 0.5–3 cm long, stamens 3; female flowers solitary, with pedicel 2–10 cm long, ovary inferior, ellipsoid, 7–9 mm long, softly spiny, stigma 3-lobed. Fruit an ellipsoid to subglobose berry 3–4.5 cm × 2–3.5 cm, on a stalk 2.5–21 cm long, beset with soft, thin spines with transparent tips, green, ripening yellow, many-seeded. Seeds ellipsoid, 5–6 mm long, compressed with rounded margins, smooth.



Cucumis anguria – 1, part of flowering stem; 2, fruit of wild plant; 3, fruit of cultivated plant. Redrawn and adapted by Iskak Syamsudin

Other botanical information The approximately 30 *Cucumis* species are native to Africa, except the cucumber (*Cucumis sativus* L.), which probably originates from India. Wild and cultivated types of *Cucumis anguria* differ in bitterness of the fruits but also in the length of fruit spines (longer in wild forms). Wild types have been distinguished as var. *longipes* (Hook.f.) A.Meeuse or var. *longaculeatus* J.H.Kirkbr., cultivated ones as var. *anguria*. However, plants with short-spined fruits are often naturalized in tropical America and rarely in Africa.

Growth and development In its native habitat in southern Africa *Cucumis anguria* germinates in a few days during the summer rains when night temperatures are above 12°C and the soil is sufficiently wet. Early growth is upright; the primary stem may reach a height of 20 cm and does not produce flowers. This is followed quickly by several trailing procumbent stems, which branch off from the base, reaching a length of 2–3 m. Male flowers appear first, followed by female ones. Plants are self-fertile and cross-pollination is by insects. Daylength plays an important role in flowering. Longer days combined with high temperatures tend to keep plants in the male-flowering phase of development, whereas lower temperatures and shorter days encourage development of female flowers. Fruits may be produced within 60 days from time of planting. They continue to be produced and to ripen over the hot season, giving up to 50 fruits per stem. Fruits remain attached to the withered annual stems long after these have died back at the end of the growing season.

Ecology Wild *Cucumis anguria* is a common

inhabitant of semi-deciduous and deciduous woodland, tree and shrub savanna, grassland and semi-desert, up to 1500 m altitude. Wild and semi-domesticated forms can be found growing near compounds, in woodland and grassland, often on abandoned cultivated land, near cattle kraals, or occasionally as a weed in cultivation.

Plants tolerate a wide range of soil types, including Kalahari sands (regosols), red clays (fersiallitics) and black cotton soils (vertisols). In its southern African habitat rainfall occurs in summer and varies from less than 400 mm to over 1000 mm. Temperatures during the growing season range from 15–35°C. *Cucumis anguria* is intolerant of frosts and cold temperatures.

Propagation and planting West Indian gherkin is propagated by seed, which requires light for germination. Seeds are sown in pockets of 3–4 at a spacing of 30 cm in the row and 100–150 cm between rows. The seed requirement is 2.5–4.5 kg/ha. In the growing season, the period from seeding to first harvest is 2–2.5 months. Plants continue to flower and set fruit for several months. For leaf production, the same cultural practices can be followed.

Management The culture and agronomic requirements are similar to those of the common garden cucumber. In cultivation, the plants should be trailed. The application of organic manure and NPK fertilizer is beneficial. Irrigation can be given in periods of drought. In South Africa, the first fruit of a plant is tasted and if it is bitter, the whole plant is discarded.

Diseases and pests West Indian gherkin is quite resistant to pests and diseases. It displays varying degrees of natural resistance to pathogens and insects, such as the cucumber green mottle mosaic virus, root-knot nematodes, powdery mildew, and greenhouse whitefly. The fruits are seldom parasitized by fruit fly larvae, which attack most other cucurbit species in southern Africa.

Harvesting As the fruits are preferred for pickling, they are harvested in the immature stage while still green. If grown for leaves, these can be picked many times during several months.

Yield A single plant can produce 50 or more fruits. No statistics on fruit or leaf yield are reported. The yield potential is probably higher than for pickling cucumbers.

Handling after harvest The fruits can be kept for a few days at room temperature, the leaves should be consumed or marketed within a day.

Genetic resources *Cucumis anguria* is not in danger of extinction in its native habitat. The National Plant Germplasm System of the USA Department of Agriculture maintains numerous accessions of cultivated types of *Cucumis anguria* at its regional plant introduction station in Ames, Iowa. Another collection is maintained at the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Turrialba, Costa Rica.

Breeding Various Western seed companies offer seed of West Indian gherkin, including 'African Heirloom', and 'West Indian Burr Gherkin'.

Cucumis anguria and related species have been the focus of investigations by plant scientists to identify resistances to the many pests (viruses, bacteria, fungi, insects) attacking cucumber and melon, which might be genetically transferred. *Cucumis anguria* proved to be totally immune to cucumber green mottle mosaic virus (CGMV). Resistance also occurred to root-knot nematodes and powdery mildew. In a study in South Africa, where fungal diseases and fruit parasitisation by Trypetid larvae is usually severe in Cucurbitaceae, *Cucumis anguria* showed a high resistance to both fungi and Trypetids. Research efforts to transfer resistances into cucumber and melon have been undertaken. Repeated attempts to hybridize different *Cucumis* species have not been entirely successful; some species have never been successfully crossed to produce a fertile F_1 generation, whereas other species have been crossed to a limited extent.

The possibility of using *Cucumis anguria* as a rootstock has been suggested, where scions of desirable crop species are grafted to it. In populations of some cucurbit species that normally produce bitter or toxic fruits, individuals may occasionally arise spontaneously which produce non-bitter, edible fruit. These variants are genetically stable when removed from the bitter gene pool. In *Cucumis anguria* a single gene distinguishes the bitter from the non-bitter type, the gene producing bitterness being dominant. Multiple factors appear to be involved in controlling bitterness, including various physiological conditions.

Prospects *Cucumis anguria* both as a semi-wild leafy vegetable and as the West Indian gherkin merits more attention from plant breeders and agronomists. It is an attractive alternative to the common garden cucumber for

use as a pickle, with fewer pest and disease problems and a larger fruit production.

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Authors M.H. Wilkins-Ellert

CUCUMIS HIRSUTUS Sond.

Protologue Harv. & Sond., Fl. Cap. 2: 497 (1862).

Family Cucurbitaceae

Chromosome number $n = 12$

Origin and geographic distribution *Cucumis hirsutus* is distributed from Cameroon to Sudan and southwards to South Africa (Cape Province); also in Madagascar.

Uses In Malawi the leaves are eaten in the same way as pumpkin leaves, i.e. sliced and cooked. The raw fruits are eaten as well, but are not much appreciated. In South Africa *Cucumis hirsutus* is considered a poisonous plant. A decoction of the root is used by the Zulu tribe to treat chronic cough.

Properties There is no information on nutritional values, but the leaf composition is probably comparable to other dark green leaf vegetables and that of the fruits to cucumber.
Several cucurbitacins have been isolated from the roots of *Cucumis hirsutus*. Cucurbitacins, which are known from many *Cucurbitaceae* and various other plant species, exhibit cytotoxicity (including antitumour activity), anti-inflammatory and analgesic activities.

Botany Dioecious, perennial, prostrate or scandent herb, with simple tendrils; roots fibrous, woody; stems up to 2.5 m long, thickened and woody at base. Leaves alternate, simple; stipules absent; petiole 0.5–5.5 cm long; blade broadly ovate, ovate-triangular or narrowly ovate, 2–15 cm × 1–10 cm, slightly cordate at base, unlobed or variously palmately 3–5-lobed, lobes ovate-triangular to linear. Flowers unisexual, regular, 5-merous; receptacle 3–9 mm long; sepals 1–9 mm long; petals white, cream or yellow; male flowers 1–12 together in fascicles, pedicel 0.5–7.5 cm long, petals up to 2 cm long; female flowers solitary or paired, pedicel 0.5–2.5 cm long, petals up to 3 cm long, ovary inferior, densely appressed or patent hairy. Fruit a globose to oblong-ellipsoid berry 2.5–7 cm × 1.5–6 cm, brownish-orange when ripe, smooth; fruit stalk 2–6 cm long, slender, not expanded upwards. Seeds ovoid, compressed, 6.5–9 mm × 5–6.5 mm × 2–3 mm, white, smooth.
The genus *Cucumis* includes about 30 species, 4 of which are economically important: cucumber (*Cucumis sativus* L.), melon and snake cucumber (*Cucumis melo* L.), West Indian gherkin (*Cucumis anguria* L.) and horned melon (*Cucumis metuliferus* Naudin). *Cucumis hirsutus* is the only species in the 'hirsutus' group of the subgenus *Melo*.
In Malawi the leaves are eaten at the end of the dry and beginning of the rainy season (October–November).

Ecology *Cucumis hirsutus* is found in woodland, wooded grassland and grassland, and as a weed on formerly cultivated ground, up to 2500 m altitude.

Management *Cucumis hirsutus* is exclusively collected from the wild.

Genetic resources and breeding Since *Cucumis hirsutus* is widespread, there is no serious risk of genetic erosion. Only in the United States are a few accessions registered, all originating from South Africa. Breeders' interest in *Cucumis hirsutus* is limited as transfer of genes by conventional breeding techniques to economically important *Cucumis* species is not possible.

Prospects It is likely that *Cucumis hirsutus* will remain a vegetable of local interest only.

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Authors C.H.Bosch

CUCUMIS MELO L.

Protologue Sp. pl. 2: 1011 (1753).
Family Cucurbitaceae
Chromosome number $2n = 24$

Vernacular names Melon, muskmelon, cantaloupe (En). Melon (Fr). Melão (Po). Mtango, mtango mungunyana, mmumunye (Sw).

Origin and geographic distribution Melon probably originated in East Africa, where wild populations still occur, e.g. in Sudan, Ethiopia, Eritrea, Somalia, Uganda and Tanzania. Possibly it also occurs wild in southern Africa, but the exact distribution of wild *Cucumis melo* is unclear because of the regular occurrence of plants escaped from cultivation. Melon was domesticated in the eastern Mediterranean region and West Asia at least 4000 years ago and subsequently spread into Asia. During the long period of cultivation many types developed with many fruit shapes and with either sweet or non-sweet flesh. Important centres of genetic diversity of cultivated melon developed in Iran, Uzbekistan, Afghanistan, China and India. In Africa important variation occurs in Sudan and Egypt. The name 'cantaloupe' derives from a 15th century introduction of melon from Turkish Armenia to the papal residence at Cantalupi near Rome. Melon is now grown worldwide. It is a typical fruit vegetable of subtropical and warm temperate areas.

Melon occurs throughout the warm and dry areas of Africa, where it is grown either for its fruit or for its seeds.

Several non-sweet types of *Cucumis melo* are grown traditionally. The most important one is snake melon, called 'ajjur', 'faqqus' or 'qatta' in Arabic. It is found in many parts of Asia, from Turkey to Japan, and locally in Europe (Italy) and the United States. In Africa it seems to be restricted to Sudan, Egypt and North Africa, where it is quite important. In Sudan the immature fruits of a melon type locally known as 'tibish' are used in the same way as snake melon. Some other types grown in Africa have bitter flesh, and are grown for their edible seeds.

Cucumis melo – planted

Uses Mature fruits of sweet melon cultivars are usually consumed fresh for the sweet and juicy pulp. The pulp is also mixed with water and sugar, or sometimes with milk, and served as a refreshing drink or made into ice cream. Immature fruits of non-sweet types, including snake melon, are used as a fresh, cooked or pickled vegetable; they are also stuffed with meat, rice and spices, and fried in oil. Snake melon is often confused with cucumber and used as such. The seeds are eaten after roasting; they contain edible oil. The Hausa people in Nigeria grind the kernels to a paste and make it into fermented cakes. The young leaves are occasionally consumed as a potherb and in soups. The leafy stems and also the fruit provide good forage for all livestock. In Réunion and Mauritius a decoction of seeds and roots is used as a diuretic and vermifuge.

Production and international trade Annual world production of melon has increased from 9 million t (700,000 ha) in 1992 to 22 million t (1.2 million ha) in 2002. Major producing countries are China with 400,000 ha, West Asia (Turkey, Iran, Iraq) 200,000 ha, the Americas (United States, Mexico, Central and South American countries) 165,000 ha, northern Africa (Egypt, Morocco, Tunisia) 110,000 ha, southern Asia (India, Pakistan, Bangladesh) 100,000 ha, European Union (Spain, Italy, France, Greece, Portugal) 95,000 ha, Romania 50,000 ha, Japan 13,000 ha and Korea 11,000 ha.

Each country has its own specific melon cultivars and most of the crop is sold in local markets. Production for export has developed in the Mediterranean region, the United States, Mexico, Australia, Taiwan and Japan, using F_1 hybrid cultivars with good shipping and storage characteristics.

In Africa sweet melon is a luxury crop for urban markets, grown in drier regions and in highlands. Statistics on production are not available for most countries, except Cameroon (3500 ha) and Sudan (1200 ha). Senegal and surrounding countries export melon during the winter to Europe.

Snake melon is important in Sudan, where it is grown for home use and local markets. The area grown is about 4000 ha with an annual production of 80,000 t. It is not exported.

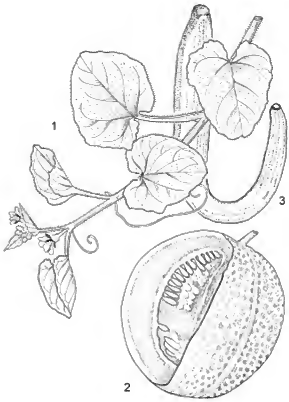
Properties The edible portion of a mature melon fruit is 45–80%. Fruits (raw, peeled) contain per 100 g edible portion: water 90.2 g, energy 142 kJ (34 kcal), protein 0.8 g, fat 0.2 g, carbohydrate 8.2 g, fibre 0.9 g, Ca 9 mg, Mg 12 mg, P 15 mg, Fe 0.2 mg, Zn 0.2 mg, vitamin A 3382 IU, thiamin 0.04 mg, riboflavin 0.02 mg, niacin 0.7 mg, folate 21 μg, ascorbic acid 37 mg (USDA, 2002).

The nutritional composition of snake melon per 100 g edible portion is: water 94.5 g, energy 75 kJ (18 kcal), protein 0.6 g, fat 0.1 g, carbohydrate 4.4 g, fibre 0.3 g, ascorbic acid 13 mg (Polacchi, W., MacHargue, J.S. & Perloff, B.P., 1982).

Sugar content and aroma are important factors determining the quality of sweet melon. Esters derived from amino acids are important components of the characteristic flavour; sulphur-containing compounds also play a role. Several C-9 alcohols and aldehydes, including Z-non-6-enal, are characteristic of the melon aroma. To get the best aroma fruits should be harvested only 2–3 days before they are fully ripe. The edible seed kernel contains approximately 46% of a yellow oil and 36% protein.

Adulterations and substitutes Snake melon for use in salads can be replaced by cucumber (*Cucumis sativus* L.).

Description Monoecious, climbing, creeping or trailing, annual herb, having simple tendrils; root system large, mostly distributed in the top 30–40 cm of the soil, a few roots descending to 1 m depth; stem up to 3 m long, ridged or striate, hairy. Leaves alternate, simple; stipules absent; petiole 4–10 cm long; blade orbicular or ovate to reniform, 3–15(–20) cm in diameter, angular or shallowly palmately 5–7-lobed, cordate at base, shallowly sinuate-toothed, surfaces hairy. Flowers axillary, unisexual or bisexual, regular, 5-merous; pedicel 0.5–3 cm long; sepals linear, 6–8 mm long; corolla campanulate, lobes almost orbicular, up to 2 cm long, yellow; male flowers in 2–4-flowered fascicles, with 3 free stamens; female or bisexual flowers solitary, with inferior, ellipsoid ovary, stigma 3-lobed. Fruit a globose, ovoid or oblongoid berry weighing 0.4–2.2 kg, smooth or furrowed, rind smooth to rough and reticulate, white, green, yellowish-green, yellow, yellowish-brown, speckled yellow or orange with green or yellow background, flesh yellow, pink, orange, green or white, many-



Cucumis melo – 1, flowering shoot; 2, fruit (rind and flesh partly removed); 3, fruit (snake melon).
Source: PROSEA

seeded. Seeds compressed ellipsoid, 5–12 mm × 2–7 mm × 1–1.5 mm, whitish or buff, smooth. Seedling with epigeal germination.

Other botanical information Most of the about 30 *Cucumis* species are native to Africa. They all have a chromosome number of $2n = 24$, except *Cucumis sativus* L. (cucumber) with $2n = 14$; probably this species originated from Asia. *Cucumis sativus* fruits are beset with spinous tubercles and warts when young, whereas ovaries of *Cucumis melo* are hairy without tubercles and warts.

Cucumis melo is polymorphic. Wild and weedy plants are often distinguished as subsp. *agrestis* (Naudin) Pangalo, having shortly pubescent ovaries and comparatively small flowers and fruits, whereas the cultivated plants (subsp. *melo*) have villous ovaries and generally larger flowers and fruits.

Cultivated plants belong to many different cultivar-groups, of which the most important with sweet fruits for modern market gardening are:

- Reticulatus Group (muskmelon or netted melon): fruit globular (1–1.8 kg), rind strongly reticulate, sometimes furrowed, yel-

lowish-green with orange flesh (Italo-American) or finely reticulate to smooth, yellowish-green with pale green flesh (Japanese, Mediterranean, e.g. 'Galia'), sugar content high (13–15%), aromatic, shelf life medium.

- Cantaloupe Group (cantaloupe or muskmelon): fruit flattish to globular and often ribbed (1.2–1.8 kg), rind smooth or reticulate, flesh usually orange, carotene and sugar content high, flavour rich, shelf life short, mainly grown in south-western Europe (e.g. 'Charentais') and the Americas.
- Inodorus Group (winter melon): fruit ovoid (1.5–2.5 kg), late maturing, rind smooth, wrinkled or slightly reticulate, often striped or splashed, grey, green or yellow, flesh firm, white or pale green, sugar content high but little flavour, shelf life long, mainly grown in Iran, Afghanistan and China, but also in Spain, the United States and Japan; important cultivars are 'Casaba', 'Honey Dew', 'Piel de Sapo', 'Jaune Canari' and 'Chinese Hami'.
- Examples of groups with non-sweet fruits used as a vegetable in Africa are:
- Flexuosus Group (snake melon or 'snake cucumber'): fruit up to 2 m long, more than 6 times as long as wide, rind pale green or striped pale and dark green, ribbed or wrinkled, flesh white.
- Tibish Group: fruit small, ovoid to oblate, without ribs, rind smooth, dark green with pale green stripes, flesh firm, white, particularly important in Sudan: a similar type named 'seinat' in Sudan is grown for its seed.

Sweet melon grown for the urban markets in tropical Africa comprises nowadays mostly F_1 hybrid cultivars of Reticulatus Group (e.g. 'Galia') and Cantaloupe Group (e.g. 'Charentais').

Growth and development Melon seed will remain viable for at least 6 years when stored dry (moisture content 6%) at temperatures below 18°C. Priming may improve germination after long storage. Seedlings appear (2–)4–8(–14) days after sowing. Numerous horizontal lateral roots develop rapidly from the taproot. The roots grow mostly at a depth of 30–40 cm. The first true leaf appears 5–6 days after unfolding of the cotyledons. The first 2–4 axillary buds on the main stem produce vigorous primary branches, which check the growth of the main stem. In most types, the first clusters of male flowers appear on the 5th–12th node of primary branches, while bisexual or female flowers appear on tertiary branches, formed from the 14th node of primary branches onwards. Flowers are open for one day only and insects, mostly bees, effect pollination. The fruit is a heavy sink for assimilates and minerals and per plant usually only 3–6 fruits will develop out of 30–100 female/bisexual flowers. The fruit development curve is sigmoid with maximum growth at 10–40 days after flowering; maturation with little further expansion occurs during the last 10 days when sugars accumulate in the fruit flesh and the net tissue on the fruit surface develops. Fruits mature 75 days (early cultivars of Reticulatus Group and Cantaloupe Group) to 120 days (Inodorus Group) after sowing. In the fruits of Reticulatus Group and Cantaloupe Group ethylene plays an essential role in the ripening process (climacteric), e.g. for flesh softening, yellowing of the rind and abscission from the pedicel. Shelf life of these fruits is short (< 1 week for 'Charentais') to medium (2–3 weeks for 'Galia'). Fruits of cultivars of Inodorus Group do not produce ethylene during ripening (non-climacteric) and consequently have a long shelf life (> 3 months for 'Piel de Sapo'). Ethylene-independent ripening processes are flesh coloration, and accumulation of sugars and organic acids.

Ecology Wild *Cucumis melo* plants occur in open woodland, especially along rivers, and as a weed in fields and waste places, up to 1200 m altitude.

Melon requires warm and dry weather with plenty of sunshine for growth and production. The optimum temperature range is 18–28°C, growth being severely retarded below 12°C. Melon easily withstands several hours per day of very high temperatures, up to 40°C. Plants are killed instantly by frost. In snake melon stem elongation was found to be greater under short 8-hour days than under 16-hour days. High humidity will reduce growth, adversely affect fruit quality and encourage leaf diseases. Melon grows best on deep, well-drained and thoroughly cultivated fertile loamy soils with pH 6–7. It does not tolerate very acid soils or waterlogged soil.

Propagation and planting Melon is usually direct-seeded: 2–3 seeds per hole, sown 2–4 cm deep on mounds or ridges, later thinned to one plant. Spacing is 50–60 cm within and 120–200 cm between the rows, giving a density of 8000–16,000 plants per ha. Alternatively, seedlings are raised in polythene pots or in soil blocks and transplanted carefully to the field when 4 weeks old, taking care not to damage the root system. The weight of 1000 seeds is (8–)25–35 g. Seed rates per ha are 1.5–2 kg for

direct-seeded melon and 0.5 kg for the transplant method. In Sudan snake melon is sown directly on raised flats of 2 m wide, in holes on both sides of the flats.

Management Melon can be grown in normal upland conditions, provided that it is rotated with non-cucurbit crops to avoid soil-borne diseases and nematodes. The soil should be ploughed, harrowed and rotavated to attain a well-pulverized and well-levelled soil. Furrow or drip irrigation is common, since plants have a high demand for water until the fruits have reached maturity. Melon is less dependent on daily irrigation than cucumber or pumpkin. During the dry season, one litre water per planting hole may be given. In Sudan an established snake melon crop is irrigated every 10–12 days during the hot rainy season (March–October), and every 14–18 days during the cool season.

Fertilizer requirements depend on crop performance and nutrient status of the soil. Removal of nutrients in a harvest of 20 t/ha of fruits is: N 60–120 kg, P 9–18 kg, K 100–120 kg, Ca 70–100 kg and Mg 10–30 kg. Melon responds well to organic manures applied at 25–30 t/ha. A complete fertilizer should be applied before sowing or planting, followed by a N topdressing when the stems are 20–30 cm long. Melon is particularly sensitive to Ca deficiency, which causes glassiness or watercore in the fruits. It is also sensitive to molybdenum deficiency, occurring in ferralitic soils. Melon is very sensitive to a number of herbicides, including Atrazine, and may even be damaged by herbicide residues from preceeding crops.

Mulching is a well-established practice in the production of melon. In subtropical areas, black, transparent or silver-painted polythene sheets are commonly used not only to control weeds but also to raise or lower the temperature of the soil. In the tropics, common mulching materials are rice straw or grass, and increasingly plastic foil. In areas where mulching materials are not available, weeding is necessary until the plants start producing long stems. Hand hoeing or pulling of large weeds is often practised. Various methods of pruning primary and secondary branches are applied to regulate vegetative growth and fruit set (3–5 fruits per plant). Snake melon is sometimes grown along a trellis to get straight fruits.

Diseases and pests Several diseases may affect melon. Gummy stem blight (*Didymella bryoniae*) causes stem and fruit stalk canker, fruit rot and plant wilting. Is a serious disease in humid and hot conditions. It is controlled by the use of disease-free seed, seed disinfection, crop rotation, spraying fungicides, and especially planting resistant cultivars. Powdery mildew (*Sphaerotheca fuliginea* and *Erysiphe cichoracearum*) can be controlled by fungicides, but modern F_1 hybrids have high tolerance to most types. Downy mildew (*Pseudoperonospora cubensis*) is important in hot and humid climates and can be controlled by fungicides; polygenically controlled resistance is available in certain Indian accessions. Anthracnose (*Colletotrichum lagenarium*) can be controlled by seed treatment, crop rotation and fungicides. Damping-off (*Pythium* sp. and *Rhizoctonia* sp.) has to be prevented by treating seed with fungicides. Bacterial soft rot or bacterial wilt (*Erwinia tracheiphila*) is controlled by removing affected plants and by eliminating the vector (striped and spotted cucumber beetle) with insecticide sprays. Angular leaf-spot (*Pseudomonas lachrymans*) is primarily a cucumber disease but occurs occasionally also in melon. *Fusarium* wilt (*Fusarium oxysporum* f.sp. *melonis*) can be effectively prevented only by resistant cultivars. In snake melon it is also a serious problem. It is most aggressive at lower temperatures (18–20°C) and does not occur in the lowlands. Sudden wilt caused by the soil-borne fungus *Monosporascus cannonballus* has become a serious problem in areas with a subtropical climate, neutral or alkaline soils, high (30–35°C) soil temperatures and use of plastic mulch; it has not yet been recorded in tropical Africa but is a potential menace.

The most frequent virus in tropical conditions is the aphid transmitted papaya ringspot virus (PRSV-W, formerly WMV-1) for which good resistance is available. Cucumber mosaic virus (CMV), watermelon mosaic virus (WMV-2) and zucchini yellow mosaic virus (ZYMV), all three transmitted by aphids, in particular *Aphis gossypii*, affect melon and predominate in subtropical conditions; there are various sources of resistance to these three viruses and also to the vector. Other virus diseases in melon are melon necrotic spot virus (MNSV), transmitted by the soil fungus *Olpidium* sp., the soil- and seedborne cucumber green mottle mosaic virus (CGMMV) and beet curly top virus (BCTV) transmitted by leafhoppers.

Root-knot nematodes (*Meloidogyne* spp.) can be a serious problem when melons are grown without proper crop rotation; control can be done by soil solarization or by wide-spectrum soil fumigants, but the latter are expensive and

hazardous to the environment.
Pests in melon are thrips (*Thrips palmi* and *Frankliniella* spp.), spider mite (*Tetranychus urticae*), aphids (*Aphis gossypii*), melon fruit fly (*Dacus cucurbitae*), cucumber beetles (*Diabrotica* spp.), leaf folder (*Diaphania indica*), leaf feeder (*Aulacophora similis*) and the fly *Bactrocera cucurbitae*, which is especially active in the humid tropics and causes young fruits to drop by tunnelling in the pedicel. Farmers usually control these pests with insecticides. However, indiscriminate use of insecticides only aggravates pest problems by destroying useful parasitic insects.

Harvesting Cantaloupe and muskmelon tend to separate from the pedicel at the base of the fruit at maturity due to the formation of an abscission layer. This is called 'full slip'. Harvesting occurs usually at the 'half slip' stage. Fruits of Inodorus Group do not form an abscission layer and maturity is indicated by colour change, e.g. from green to yellow. Tender immature pale green fruits of snake melon are harvested starting 45–60 days from sowing. Harvested fruits are about 20 cm long with a diameter of 3 cm, weighing 90–100 g. If the fruits are left for seed, they are harvested when fully ripe.

Yield On average yields of fresh melon fruits reach 18 t/ha, ranging from 5–40 t/ha depending on cultivar and cultural practices. Seed yields are about 300–500 kg/ha for open-pollinated and 100–200 kg/ha for hybrid cultivars. The yield of a snake melon crop in Sudan is on average 20 t/ha.

Handling after harvest Muskmelon fruits for storage should be cooled to 10–15°C immediately after harvesting to retard ripening. Storage for 10–15 days at 3–4°C (90% relative humidity) is possible, but lower temperatures can cause chilling injury. 'Honeydew' and other winter melon fruits can be stored at 10–15°C for longer periods, some cultivars up to 90 days. Heavily netted melon fruits (e.g. the Mediterranean 'Galia' and American 'Western Shipper') are relatively resistant to handling and transport. The fruits of snake melon are packed in plastic or jute sacs for transport to near-by town markets. They are treated in the same way as cucumber fruits.

Genetic resources The genetic diversity within *Cucumis melo* is fairly well preserved in germplasm collections. The most extensive collections are maintained in the United States (North Central Regional Plant Introduction Station, Ames IA), Russian Federation (N.I. Vavilov All-Russian Scientific Research Institute of Plant Industry, St. Petersburg), China (Institute of Crop Germplasm Resources (CAAS), Beijing), but many other countries hold significant collections. In Africa important collections are held at National Horticultural Research Institute, Ibadan, Nigeria and Agricultural Research Corporation, Wad Medani, Sudan. The melon germplasm collections preserved in Wad Medani include about 70 accessions of snake melon and 45 of the local vegetable melon 'tibish'. The germplasm collections could be complemented by further collection of germplasm in the secondary centres of genetic diversity in Afghanistan, India, China, Pakistan and Sudan. Some cultivar-groups with small fruits close to wild types appear to be particularly good sources of host resistance to major melon diseases.

Breeding Much of the cultivar improvement in melon is based on mass and line selection in open-pollinated populations. However, these are now rapidly giving way to F_1 hybrid cultivars, especially in Europe, the United States, Japan and Taiwan. Pure-line development in melon is easy, as there is practically no inbreeding depression after repeated selfing. On the other hand, there is also little hybrid vigour in hybrids between inbred lines. The main advantages of F_1 hybrids are, however, uniformity of plant and fruit type and recombination of favourable characteristics of different melon types in one genotype: fruit quality (round shape, good flavour, high sugar content, small seed cavity), long shelf life, adaptation to more humid climates and especially resistance to diseases and pests.
Most cultivars have male as well as bisexual flowers on the same plant, and F_1 hybrid seed production requires emasculation of the bisexual flowers followed by hand pollination. Monoecious plant types would enable hybrid seed production with bee pollination, as the female parent line can be temporarily induced to produce female flowers only by sprays with ethrel. However, the change to monoecious F_1 hybrids is slowed down by the fact that monoecy in melon is linked to elongated shape and large size of the fruits, while the aim for cantaloupe and muskmelon is round and compact fruits. However, monoecious F_1 hybrids are now becoming increasingly common.
The main breeding objectives for snake melon are disease and insect resistance and better fruit quality. Breeding for resistance is a top priority because the fruit is often consumed

fresh, making it hazardous to use chemicals, especially where restrictions are not observed. Breeding for quality aims at producing cultivars with slender and tender fruits for the fresh consumption in green salads.
In a recent evaluation study of melon germplasm collected from Sudan, several snake melon accessions were found, including resistant plants to some types of Fusarium wilt and *Sphaerotheca fuliginea*. Crosses with normal melon are easy and occur spontaneously. Resistance to Fusarium wilt was also detected in some accessions of Tibish Group and wild populations of *Cucumis melo*, known locally in Sudan as 'humaid'. Resistance to some viral diseases, especially ZYMV, was also detected in some accessions of 'humaid'.

Prospects Melon is well liked by most people and the importance of this crop will further increase through better adaptation to hot and humid growing conditions. A factor limiting melon production is the multitude of diseases (viruses in particular) and pests. New techniques from cellular (protoplast fusion) and molecular (genetic transformation, DNA markers) biology are now within reach of the melon breeders. This has opened up prospects for exploiting germplasm from other *Cucumis* species for disease and pest resistance and other characteristics, not available through conventional interspecific hybridization.
Snake melon is adapted to hot and dry conditions, which makes it interesting for further expansion to some African regions outside Sudan. Germplasm collection and breeding need more attention.

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Authors H.A.M. van der Vossen, I.M. El Tahir & M.O. Oluoch

Based on PROSEA 8: Vegetables.

CUCUMIS METULIFERUS E.Mey. ex Naudin

Protologue Ann. Sci. Nat. Bot., sér. 4, 11: 10 (1859).

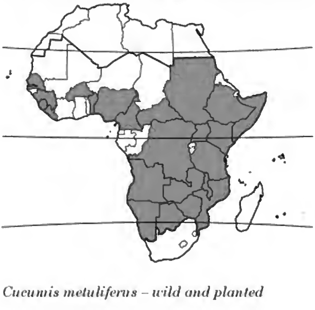
Family name Cucurbitaceae

Chromosome number $2n = 24$

Vernacular names Horned melon, African cucumber, horned cucumber, kiwano (En). Concombre cornu, métulon, kiwano (Fr). Maxije (Po).

Origin and geographic distribution *Cucumis metuliferus* occurs naturally throughout the tropical and subtropical sub-Saharan regions of Africa, from Senegal to Somalia and South Africa. It has also been recorded in Yemen. In Kenya, New Zealand, France and Israel the fruits of improved cultivars are commercially grown for export. *Cucumis metuliferus* has become naturalized in Australia, and is reported as adventive in Croatia.

Uses The fruits of horned melon are mainly eaten, and in some parts of Africa the leaves are also used as a vegetable. The fruits are peeled and eaten in either the immature or the mature stages. Fruits in the unripe stages have the appearance and taste of cucumber. Mature fruits may have a sweet dessert-fruit flavour. Mature fruits may also be split open and dried in the sun for later use. In Botswana the Kalahari San people prepare the fruits by roasting. In Zimbabwe young leaves are stripped from



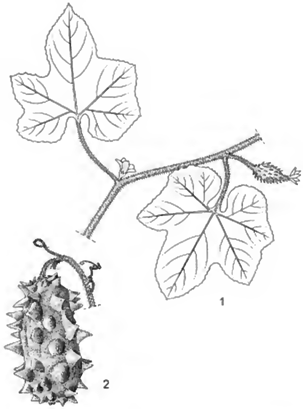
Cucumis metuliferus – wild and planted

the stems, washed and boiled as spinach, in the same way as musk pumpkin leaves (*Cucurbita moschata* Duchesne), adding peanut butter prior to serving.
Fruits from wild-growing plants are often bitter and inedible. Traditional medical practitioners in Zimbabwe consider the bitter wild fruits as poisonous if taken by mouth. The root is used in the Mutare area (Zimbabwe) for the relief of pain following childbirth. In Benin the fruit is said to possess medico-magical properties and is used to treat eruptive fevers in 'Sakpata voodoo' rituals. The decorticated fruit macerated in distilled palm wine or lemon juice is used to treat smallpox and skin rashes.
In Western countries *Cucumis metuliferus* is currently mostly marketed as an ornamental for its decorative fruit, with a unique appearance and extended keeping qualities.

Production and international trade In southern Africa horned melon is considered a traditional fruit vegetable. Cultivation has been on a small scale, e.g. in Zimbabwe it is cultivated in rural and peri-urban areas for sale in traditional markets and by street vendors. The development of the African horned melon into an international crop started in New Zealand where it has been commercially grown and exported since the 1980s. There it was given the name 'kiwano' in an attempt to promote the new fruit crop in Japan and the United States. Since then it has also been grown commercially to a limited extent in California for the United States market, and in Israel and Kenya from where the fruits are exported to markets in Europe. Recent efforts to grow the crop during the summer in southern France for the European market have been successful.

Properties The nutrient content for fresh fruits of *Cucumis metuliferus* (per 100 g edible portion) is: water 91.0 g, energy 134 kJ (32 kcal), protein 1.1 g, fat 0.7 g, carbohydrate 5.2 g, crude fibre 1.1 g, Ca 11.9 mg, Mg 22.3 mg, P 25.5 mg, Fe 0.53 mg, thiamin 0.04 mg, riboflavin 0.02 mg, niacine 0.55 mg, ascorbic acid 19 mg (Wehmeyer, A.S., 1986). Some values may vary depending on fruit maturity, as the fruits are eaten at both immature and mature stages. The leaf composition is approximately the same as other dark green leafy vegetables.
In wild *Cucumis metuliferus*, plants with bitter and non-bitter fruits occur, and the two types are morphologically indistinguishable. A significant proportion of wild-growing horned melon plants encountered in southern Africa are bitter-fruited and have caused poisoning. Bitter mature fruits may remain completely intact on the plants, as neither baboons nor other wildlife eat them. The amount of bitterness varies in immature and mature fruits on the same plant, with younger fruits having a less bitter taste. Bitterness is due primarily to the presence of cucurbitacins, bitter and toxic compounds occurring in *Cucurbitaceae*. Cucurbitacins can cause severe illness and death, due to their potent action as purgatives and laxatives. *Cucumis metuliferus* contains cucurbitacin B, a triterpene known to exhibit cytotoxic, antitumour and anti-inflammatory activities.

Description Vigorous annual herb with climbing or prostrate stems, having solitary, simple tendrils 4–10.5 cm long; root system strong, fibrous; stems reaching several m in length, grooved, with long stiff spreading hairs. Leaves alternate, simple; stipules absent; petiole 3–12 cm long, setose; blade ovate or pentagonal in outline, 3.5–14 cm × 3.5–13.5 cm, shallowly palmately 3–5-lobed, hispid setulose especially on veins below, becoming scabrid-punctate. Flowers unisexual, regular, 5-me-



Cucumis metuliferus – 1, part of stem with male and female flower; 2, fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

rous; sepals filiform, 2–4 mm long; petals united at base, 0.5–1.5 cm long, yellow; male flowers in 1–10-flowered fascicles, with pedicel 2–18 mm long, stamens 3; female flowers solitary, with pedicel 5–35 mm long, ovary inferior, ellipsoid, 1–2.5 cm long, covered with large soft spines, stigma 3-lobed. Fruit an oblong-cylindrical berry 6–16 cm × 3–9 cm, on a stalk 2–7 cm long, rounded at both ends and beset with stout, broad-based, spiny protuberances 1–1.5 cm long, dark mottled green, ripening through yellow to bright orange, many-seeded. Seeds narrowly ovoid, 5–8 mm long, compressed with rounded margins, sericeous hairy.

Other botanical information Most of the approximately 30 *Cucumis* species are native to Africa, but the cucumber (*Cucumis sativus* L.) probably originates from India. *Cucumis metuliferus* with its 'horned fruits' and hairy seeds is genetically more closely related to melon (*Cucumis melo* L.) than cucumber, but has proven to be cross-incompatible with other species. Based on meiotic and crossing studies, flavonoid patterns, chloroplast DNA data, and isozyme analyses, *Cucumis metuliferus* is isolated from the other species in the genus. Specimens with non-bitter fruits, totally lacking spiny protuberances, have been observed both in the wild and under semi-cultivated conditions near Bulawayo (Zimbabwe).

Growth and development At optimum temperatures of 20–35°C seed germination takes place in 3–8 days. Below 8°C germination is completely inhibited. Vegetative stem growth, either climbing or sprawling, exhibits typical cucurbit exuberance and the plants are capable of smothering nearby plant growth. Flowering starts about 8 weeks after sowing, with male flowers appearing first, followed after several days by female flowers. Pollination is by insects. In experiments in Israel maximum fruit weight (on average 200 g) was reached 30–40 days after pollination, and the main period of fruit ripening on the plant in terms of changes in fruit constituents and colour (from green to yellow) occurred 37–51 days after pollination. Under field conditions, time from sowing to harvest was 3.5 months.

In Zimbabwe, sweet-fruited plants reseed themselves with little management and protection. Fruits continue to be sweet, barring the occasional pollination by bitter-fruited wild plants. Fruits of horned melon in southern Africa continue ripening after the cessation of the rainy season, long after the stems have died back.

Ecology The natural habitat of horned melon ranges from low-altitude riverine semi-evergreen forest to semi-arid highlands and Kalahari sands. Horned melon is a warm-season grower in tropical to subtropical regions, and does not tolerate cold conditions. It occurs at altitudes from near sea level to 1800 m. In southern Africa seeds germinate with the summer rains when night temperatures are above 12°C. A semi-arid climate with a warm-season rainfall regime appears to enhance the fruit ripening stage, allowing fruits to develop their full flavour. Plants tolerate a wide range of soil types throughout their natural distribution area.

Propagation and planting *Cucumis metuliferus* is propagated by seed. The 1000-seed weight is about 14 g. Seed may be sown directly or seedlings are transplanted when they have two true leaves. The optimum time of planting is when soil and air temperatures are above 14°C. A planting density of 10,000 plants per ha produced good yields in Israel. In Spain direct planting of seed retarded production; the use of transplants with well-developed root systems was recommended.

Management Horned melon may be grown under field conditions similar to cantaloupe melon or cucumber. In Spain field-grown plants using supports did not produce as satisfactorily as those grown without, and this was thought to be due to climatic factors, principally the wind. Greenhouse planting is an option in which case pollinators must be introduced at the time of flowering. According to local soil conditions and soil test recommendations, compost, manure or inorganic fertilizers can be incorporated.

Diseases and pests In southern Africa horned melon plants are seldom affected by diseases or pests in their natural habitat. *Cucumis metuliferus* is susceptible to cucumber mosaic virus, tobacco ringspot virus, tomato ringspot virus, watermelon mosaic virus 2, and a severe strain of bean yellow mosaic virus. Some accessions are susceptible to Fusarium wilt (*Fusarium oxysporum*). Plantings in Israel were affected by powdery mildew (*Sphaerotheca fuliginea*) and squash mosaic virus. Greenhouse plantings in Spain, with high temperatures and humidity, were affected by powdery mildew (*Erysiphe cichoracearum*) and the greenhouse white fly (*Trialeurodes vaporariorum*), but field plantings were unaffected. African horned melon is resistant to the musk

melon yellow virus. Some accessions are highly resistant to watermelon mosaic virus 1, due to a single completely dominant gene, and hypersensitive-resistant to squash mosaic virus.
An orange and black cucurbit beetle, *Sonchia pectoralis*, has been observed damaging the leaves of young plants, but not to the extent of harming overall growth. The ubiquitous pumpkin fly, which ravages other cucurbit crops in southern Africa, does not attack horned melon.
Horned melon is highly resistant to root-knot nematodes (*Meloidogyne* spp.). Resistance to powdery mildew, melon aphid (*Aphis gossypii*), greenhouse white fly and Fusarium wilt has been recorded in several accessions.

Harvesting Stems of horned melon die back at the end of the growing season while the fruits remain attached and continue ripening to a bright orange colour. They may be harvested over successive months. Immature fruits may be harvested at any time during the growing period. Care is needed during picking because the stiff sharp hairs on the stems and the spiny 'horns' on the fruits can easily puncture the skin; it is recommended that gloves be worn for harvesting. For home consumption leaves are picked from plantings or are collected from wild plants.

Yield There are no records on yield from Africa. In New Zealand growers harvest up to 20 t/ha of horned melon fruits, in California about 8 t/ha. Growers in Israel harvested approximately 230,000 fruits/ha, fruits weighing on average 200 g, totalling 46 t/ha. Results of experiments conducted in Spain showed that each plant produced on average 66 fruits weighing 15 kg.

Handling after harvest Fruits should not be stacked without protective covering; the sharp spines easily puncture the skin of other fruits, causing a dark-orange to reddish discharge from the wounds. The spines may be rendered less harmful by use of sandpaper or a file. Fruits have an exceptionally long keeping quality at room temperature and may be kept for many months without losing their decorative appeal. Fruits picked at the onset of ripening and kept at 24°C were undamaged after three months of storage, though they failed to develop the desired orange colour. Ethylene treatment resulted in fruit colour changing from green to yellow in three days, but had no effect on total soluble solids levels. There was a rise in reducing sugars during storage, unrelated to ethylene treatment. Fruit ripened on the stem showed higher values for total soluble solids and reducing sugars. At 20°C 30% spoilage among stored fruits occurred by day 37, and at storage temperatures below 12°C all ripe fruits spoiled within 55 days. Chilling symptoms in the form of opaque rind spots appeared on the fruit surface when fruits were stored at 4°C; cold storage is therefore not recommended.

Genetic resources Germplasm of horned melon is held at the National Plant Genetic Resources Centre in Windhoek, Namibia, and in the United States (Department of Agriculture, North Carolina Plant Introduction Station). In the wild *Cucumis metuliferus* is widespread and occurs in a variety of habitats, so there is no reason to consider it liable to genetic erosion.

Breeding Fruit quality in horned melon is measured by colour, size, taste, acidity and aroma. Original cultigens tested were found somewhat lacking in the taste factor, however these lines were being tested for plant vigour and pest and disease resistances. There is a need to identify sweet-fruited cultivars. More recent studies with germplasm from Botswana and Zimbabwe showed promising results for increased size and improved taste. Within the germplasm being grown in Zimbabwe and South Africa, cultivars are found with large (up to 18 cm) fruits; they are orange when ripe and have pleasantly tasting flesh, used as an attractive ingredient in fruit salads. *Cucumis metuliferus* possesses important genes for disease and pest resistance that would be of benefit to the gene pool of other commercially important *Cucumis* species, i.e. musk melon and cucumber, if they could be transferred. However, many attempts by various research groups to introduce these genes using traditional sexual hybridization methods have not been successful due to strong incompatibility barriers. Neither embryo culture nor somatic hybridization by protoplast fusion has produced successful results to date.

Prospects The prospects for horned melon as a subsistence leafy vegetable are rather poor, but as a cultivated cucumber-like vegetable or dessert fruit it has a bright future. The immature green fruits are highly prized in Zimbabwe. Because of the somewhat insipid taste of the cultivars being grown, it has not caught on as a dessert fruit or cucumber substitute in the United States and Europe to the extent that marketers had hoped. Until the flavour can be improved to the satisfaction of the consumer, the present marketing technique

for horned melon is as a decorative ornamental fruit. Given its unique form and appearance, together with its appealing orange-ripe colour plus an extended shelf life, *Cucumis metuliferus* rightfully deserves centerpiece fruit-bowl attention. The preferred climate pattern of warm-season rain followed by a dry cool season could be an important consideration in any future successful commercial growing venture.

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Sources of illustration Berhaut, J., 1975a; Jeffrey, C., 1978.

Authors M.H. Wilkins-Ellert

CUCUMIS MYRIOCARPUS Naudin

Protologue Ann. Sci. Nat. Bot., sér. 4, 11: 22 (1859).

Family Cucurbitaceae

Chromosome number $2n = 24$

Synonyms *Cucumis leptodermis* Schweick. (1933).

Vernacular names Gooseberry cucumber, prickly paddy cucumber (En).

Origin and geographic distribution *Cucumis myriocarpus* originates from Zambia, Botswana, Zimbabwe, Mozambique, South Africa and Lesotho. It has been introduced in several other regions, and has become naturalized in southern Europe, California and Australia. Locally it is considered a weed; in California it has been declared noxious.

Uses Leaves of *Cucumis myriocarpus* are collected in the wild for use as a cooked vegetable. The fruit pulp is widely used as an emetic and purgative. Overdosing and/or inclusion of seeds in the pulp have been blamed for fatal cases of poisoning. *Cucumis myriocarpus* is suspected of causing photosensitization in sheep and blindness in cattle. However, reports on medicinal use and toxicity of *Cucumis myriocarpus* are suspected of wrong identification, and may refer to other species.

Properties The nutritive value of the leaves is unknown, but probably it is comparable to *Cucumis africanus* L.f. leaves and other dark green leaf vegetables. Fresh fruits of *Cucumis myriocarpus* contain cucurbitacins A and D. Cucurbitacins, which are known from many *Cucurbitaceae* and various other plant species, exhibit cytotoxicity (including antitumour activity), anti-inflammatory and analgesic activities.

Botany Annual, monoecious, prostrate or scandent herb, with simple tendrils; stems up to 2 m long. Leaves simple, alternate; petiole 1.5–10 cm long; blade broadly ovate, very deeply palmately 5-lobed, 2.5–10 cm × 2–7.5 cm, shallowly cordate at base, lobes elliptical, each again rather deeply 3–5-lobed. Flowers unisexual, regular, 5-merous; receptacle 2–5 mm long; sepals 1–3 mm long; petals 3–6(–10) mm long, pale yellow; male flowers 1–2 (rarely more) together, pedicel 0.5–2.5 cm long, stamens 3; female flowers solitary, together with male, pedicel 1.5–4.5 cm long, ovary shortly and softly spiny. Fruit a globose to ellipsoid berry 3–6(–9) cm × 1.5–2.5 cm, with spines up to 2 mm long; fruit stalk 4.5–7 cm long, slender. Seeds ellipsoid, 5–6 mm × 2.5–3 mm × 1–1.5 mm.

The genus *Cucumis* includes about 30 species, 4 of which are economically important: cucumber (*Cucumis sativus* L.), melon and snake cucumber (*Cucumis melo* L.), West Indian gherkin (*Cucumis anguria* L.) and horned melon (*Cucumis metuliferus* Naudin). *Cucumis myriocarpus* is placed in the 'anguria' group of the subgenus *Melo*. Two subspecies are distinguished based on fruit characteristics: subsp. *leptodermis* (Schweick.) C.Jeffrey & P.Halliday is confined to South Africa, subsp. *myriocarpus* has a much wider distribution and differs from the former by its fruits having a more distinct pattern of stripes (dark green, pale green, white, purplish, brown and rusty orange) and being densely covered with spines.

Ecology *Cucumis myriocarpus* is found in

open localities in grassland and wooded grassland, especially on sandy soils at altitudes of 350–2000 m. It is frequently found as a weed of cultivated land and irrigation furrows.

Management In southern Africa *Cucumis myriocarpus* is an important weed in maize fields. Poisoning of cattle grazing the stubble of weedy fields is a serious risk. As a weed it can easily be controlled mechanically.

Genetic resources and breeding As *Cucumis myriocarpus* is widespread and common, it is not threatened by genetic erosion. There are genebank accessions recorded in Germany, the Czech Republic, Spain, the United Kingdom and the United States.
Within the 'anguria' group of about 16 spiny-fruited *Cucumis* species to which *Cucumis anguria* belongs as well, there are no major barriers to gene exchange. Several interspecific crosses have been made in this group. Individual plants of *Cucumis myriocarpus* have been found with intermediate resistance to downy mildew (*Pseudoperonospora cubensis*) and resistance to scab (*Cladosporium cucumerinum*).

Prospects As a vegetable *Cucumis myriocarpus* will remain only locally of some importance and its spread is to be discouraged. It is promising as a source of disease and pest resistance for economically important *Cucumis* species.

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Other references Kirkbride Jr., J.H., 1993; Meeuse, A.D.J., 1962; Schippers, R.R., 2000.

Authors C.H. Bosch

CUCUMIS SATIVUS L.

Protologue Sp. pl. 2: 1012 (1753).
Family Cucurbitaceae
Chromosome number $2n = 14$

Vernacular names Cucumber, gherkin (En). Concombre, cornichon (Fr). Pepino (Po). Tango (Sw).

Origin and geographic distribution *Cucumis sativus* is believed to have originated in the southern Himalayan foothills region of Asia. The wild *Cucumis sativus* var. *hardwickii* (Royle) Gabaev (synonym: *Cucumis hardwickii* Royle), which is seen as the possible progenitor, can still be found there. It has small, very bitter, spiny fruits, and is fully compatible with *Cucumis sativus*. An alternative view, however, suggests that var. *hardwickii* is a derivative

Cucumis sativus – planted

that escaped from cultivation.
Cucumber is said to have been cultivated in India for at least 3000 years and in eastern Iran and China probably for 2000 years. China is considered a secondary centre of genetic diversification. Cucumber was carried to Europe before our era and was introduced into the New World by early travellers and explorers. In tropical Africa it probably arrived first in the west with the Portuguese. Cucumber is now cultivated worldwide. In tropical Africa it can be found on all city markets and is common in most supermarkets.

Uses The main use of cucumber is for the immature fruit in salads, either with the skin or peeled. Fruits are sliced or cut into pieces and served with vinegar or a dressing, on their own or mixed with other vegetables. Young fruits of special small-fruited cultivars called 'gherkin' are pickled in vinegar. Young or ripe cucumber fruits are occasionally used as cooked vegetables or made into chutney. Locally in Asia types with large, white or yellow fruits are boiled and eaten as an ingredient of stews, young shoots are consumed as a leafy vegetable, and seeds are consumed or used to extract an edible oil, but these uses have not been recorded for Africa. In tropical Africa cucumber is considered an exotic or Western vegetable of relatively recent introduction, mostly used by city consumers. However, it is rapidly gaining popularity in the African kitchen; in East Africa it is regularly used in 'kachumbari', a kind of African coleslaw.
Ripe raw cucumber fruits are said to cure sprue, and in Indo-China cooked immature fruits are given to children to treat dysentery.

The seed has some anthelmintic property. Cucumber extract is known to have cleansing, soothing, and softening properties; it is used as an ingredient in a variety of health and beauty products for the skin. Cucumber peel when eaten by cockroaches is reported to kill them after several nights. Non-food uses of cucumber are not common in Africa.

Production and international trade In 2002 the world area under *Cucumis sativus* was estimated at about 2 million ha, with a total production of 36 million t. Asia is the world leader, with China alone accounting for over 60%. Cucumber is grown in all countries of tropical Africa, but nowhere on a large scale. In 2002 Africa produced 507,000 t on 25,000 ha, accounting for just under 1.5% of production. Egypt is the largest African producer with 360,000 t. Detailed data on countries of tropical Africa are lacking. International trade in 2002 amounted to 1.5 million t, with Mexico, the Netherlands and Spain as the main exporters; international trade from African countries is modest and unrecorded.

Properties The nutritional composition of cucumber per 100 g edible portion (ends trimmed, not peeled, edible part 97%) is: water 96.4 g, energy 42 kJ (10 kcal), protein 0.7 g, fat 0.1 g, carbohydrate 1.5 g, dietary fibre 0.6 g, Ca 18 mg, Mg 8 mg, P 49 mg, Fe 0.3 mg, Zn 0.1 mg, carotene 60 µg, thiamin 0.03 mg, riboflavin 0.01 mg, niacin 0.2 mg, folate 9 µg, ascorbic acid 2 mg (Holland, B., Unwin, I.D. & Buss, D.H., 1991). The edible portion is about 85% when peeled. Seed kernels contain approximately 42% oil and 42% protein.
The bitter principle cucurbitacin C occurs in *Cucumis sativus*. Cucurbitacins are terpene components in the foliage and fruits, the evolutionary role being to protect the plant against herbivore attack. As a result of breeding, modern cultivars are not bitter. The presence of a saponin and the slightly poisonous alkaloid hypoxanthine might explain the anthelmintic property of the seed.

Adulterations and substitutes The fruits of *Cucumis anguria* L., the West Indian gherkin, may replace those of *Cucumis sativus* for pickling, and the fruits of snake melon (*Cucumis melo* L.) for pickling and fresh use.

Description Annual monoecious herb with trailing or scandent stems up to 5 m long, having simple tendrils up to 30 cm long; stem 4–5-angled, sparingly branched, with bristle-like hairs; root system extensive and largely superficial. Leaves alternate, simple; stipules absent; petiole 5–20 cm long; blade triangular-ovate in outline, 7–20 cm × 7–15 cm, palmately 3–7-lobed, deeply cordate at base, acute at apex, toothed, bristly hairy. Flowers unisexual, regular, 5-merous; sepals narrowly triangular, 0.5–1 cm long; corolla widely campanulate, lobes up to 2 cm long, yellow; male flowers in 3–7-flowered fascicles, with pedicel 0.5–2 cm long, stamens 3; female flowers solitary, with pedicel short and thick up to 0.5 cm long, lengthening in fruit up to 5 cm, ovary inferior, ellipsoid, 2–5 cm long, prickly hairy or warty, stigma 3-lobed. Fruit a pendulous, globose to cylindrical berry up to over 30 cm long, often slightly curved, beset with spinous tubercles and warts when young, skin usually green, but in some cultivars white, yellow or brown, flesh pale green, many-seeded. Seeds ovate-oblong in outline, 8–10 mm × 3–5 mm, compressed, white, smooth. Seedling with epigeal germination.

Cucumis sativus – 1, flowering and fruiting shoot; 2, female flower in longitudinal section; 3, fruit.
Source: PROSEA

Other botanical information With their chromosome number of $2n = 14$, cucumber and its wild relative are different from all other members of the genus, which have $2n = 24$. It

is also the only *Cucumis* species thought to have originated in Asia; the other species are indigenous to Africa. *Cucumis anguria* is often confused with the small cucumber types that are used for pickles, since both are commonly called 'gherkin'.

A satisfactory classification of the cultivated cucumber does not exist. A large variation of fruit shapes, sizes, colours and rind characteristics can be found in different combinations, and numerous cultivars have been developed all over the world. Commonly cultivated types include:

- American slicer: fruits dark green, smooth-skinned but quite spiny, medium-sized; popular open-pollinated cultivars grown worldwide are 'Marketmore 76', 'Poinsett 76', 'Ashley', and the hybrids 'Cyclone' and the gynoecious 'Dasher II'; the hybrid 'Kande' was specifically developed for tropical climates by East-West Seed Company; popular open-pollinated cultivars, as well as hybrids such as 'Tokyo' and 'Olympic' are distributed in Africa by Technisem.
- European greenhouse cucumber: fruits very long, slim, nearly spineless but with a rough skin, grown in greenhouses; cultivars are all hybrids, gynoecious and with parthenocarpic fruit, e.g. 'Mystica' and 'Sabrina'.
- Beit Alpha: mainly grown in and around the Middle East; fruits medium-sized, with a somewhat ribbed though spineless skin; often gynoecious and/or parthenocarpic, e.g. the hybrids 'Basma' and 'Excel', distributed in Africa by Technisem.
- Pickling cucumber: usually a bit smaller than slicers, around 15 cm or less, often with prominent warts, used for production of pickled fruits (gherkins); common and popular cultivars are 'Calypso' and 'Eureka', bush types such as 'Little Leaf' require less space and set fruits simultaneously.
- White cucumber: grown in India, Sri Lanka, and other Asian countries; fruits with white smooth skin, medium- to large-sized; a popular cultivar is 'Long White', hybrids are also available, e.g. 'Keisha' from East-West Seed Company and 'Shivneri' from Seminis.
- Asian or mottled cucumber: popular in many southern and eastern Asian countries; many hybrids are available in fruit sizes ranging from mini (around 7 cm), e.g. 'Kiros' (East-West Seed Company), to medium-sized, e.g. 'Ninja' (Chia Tai) and 'Kasinda' (East-West Seed Company).
- Chinese and Japanese (oriental) cucumber: fruits relatively long, slim, rather spiny; in southern China sometimes with black spines, in Japan perfect size 22 cm × 2–3 cm, white-spined; Chinese cultivars include 'Beijing Dachi' and 'Ganfeng 3' from GAAS, popular Japanese hybrid cultivars are 'Sharp 1' and 'Nao-Yoshi' from Saitama Gensyu Ikuseikai.

In tropical Africa mainly slicing cucumber is grown, for which mostly the open-pollinated cultivars 'Ashley' and 'Poinsett' are used. Beit Alpha types are also grown, especially in northern Africa. Pickling cucumber is planted as well, but this may often be *Cucumis anguria* instead of *Cucumis sativus*.

Growth and development Germination takes 3 days at optimum temperatures. Flowering normally starts 40–45 days after sowing, but early cultivars such as 'Kiros' can start flowering within 30 days. The female flowers develop later than the more numerous male flowers. The ratio male/female flowers largely depends on daylength, temperature and cultivar. Long days and high temperatures tend to keep the plants in the male phase or change the ratio to a higher male proportion.

Several growth regulators can be used to influence sex expression; spraying of ethephon induces female flowering. Many modern cucumber cultivars are gynoecious (having only female flowers). To increase seed of a gynoecious line, or to use it as a male parent, spraying with silver nitrate, silver thiosulfate or gibberallic acid will induce male flowering. Concentration and duration of spraying depend on the genotype and the intended result; usually spraying can start at the 2–3 true leaf stage, and can be repeated every 2 days for up to 5 times.

For gynoecious or highly female cultivars that are not parthenocarpic, commercial seed is usually mixed with 10–15% of a highly male line. Bees are the main pollinating agents and should be sufficiently available for good fruit development. Poor pollination results in deformed or curved fruits. However, the European parthenocarpic greenhouse cucumber should not be pollinated, since this will result in unwanted seeded fruits and fruit deformation. Greenhouses are therefore kept insect free to prevent pollination.

Fruits are harvested 1–2 weeks after flowering, depending on the genotype, usually before they are physiologically mature. Frequent harvesting of immature, marketable fruits will result in a continuation of new fruitset and a longer life cycle of the crop. Large, maturing fruits

that are left on the plant inhibit the development of additional fruits. Very early, field-grown cultivars can senesce quickly and may die after only 2–3 months, especially when diseases start to affect the plants during fruit setting stage. The crop cycle of cucumber grown in glasshouses in Europe can be extended to around 6 months under specific conditions.

Ecology Cucumber requires a warm climate. In cool, temperate countries it is grown in greenhouses; only during hot summers can it be grown in the open. The optimum temperature for growth is about 30°C and the optimum night temperature 18–21°C; the minimum temperature for good development is 15°C. Pickling cultivars are usually more adapted to low temperatures. Sensitivity to daylength differs per cultivar; short daylengths usually promote vegetative growth and female flower production. High light intensity is needed for optimum yields. Cucumber needs a fair amount of water but it cannot stand waterlogging. Low relative humidity results in high plant evaporation due to the large leaf area, and sufficient irrigation is then very important. High relative humidity facilitates the occurrence of downy mildew. The soil should be fertile, well-drained, with a pH of 6.0–7.0. In tropical Africa elevations up to 2000 m appear to be suitable for cucumber cultivation.

Propagation and planting Cucumber is propagated by seed. The 1000-seed weight ranges from 20–35 g. During soil preparation generous incorporation of organic manure (about 25–35 t/ha) is required. About 1–3 kg of seed is needed per ha depending on the method of sowing. Direct sowing, which is still a common practice especially in open fields, requires larger amounts of seed. The use of transplants will result in a more uniform crop stand, if done properly. In open fields in the tropics seedlings can already be transplanted after around 7 days or at the 2-true-leaf stage, but in cooler areas or for greenhouse production much older transplants of up to 33 days are used. When direct sown, cucumbers are planted on hills, 90–120 cm apart, with several seeds per hill and thinned to 2–3 plants, or they are sown in rows 1–2 m apart and thinned to 30 cm between plants. When planted as a ground crop the wider distances are used, whereas for trellised crops closer planting can be applied. Cucumber cultivated for pickles is planted closer, up to 250,000 plants/ha.

Management Planting on raised beds will improve drainage, which is especially important during the rainy season, and can support good root development. The use of plastic mulch makes weed control and water management easier, and can help in reducing insect populations at an early stage. Weed control is necessary until the plants cover the soil entirely. Support (stakes) can be provided, which will generally improve fruit quality, reduce disease incidence through better air circulation in the crop, and make it easier to pick the fruits. Irrigation is required at short intervals; a high level of soil moisture should be maintained throughout the growing period. The use of drip irrigation is highly recommended for an optimum and uniform use of available water.

Fertilizers can be included in the drip system. Cucumber responds well to fertilizers. In addition to the initial organic manure, a general recommendation is 700 kg/ha of an NPK mixture, followed by N fertilizer every 2–3 weeks until the fruits form. However it is always best to base fertilizer gifts on a soil analysis before planting. Micronutrients are also essential for a good development; shortages can result in strong deficiency symptoms in both plants and fruits, leading to lower and low quality yields.

The tip of the main stem may be nipped off to encourage branching; in plants with very strong vegetative growth lateral shoots may be pruned after the first fruits have formed to limit leaf and flower production. Excessive use of N promotes stem growth and the production of male flowers.

Diseases and pests Many diseases and pests can affect cucumber in all stages of development. Leaf diseases that can result in serious damage are the fungal diseases downy mildew (*Pseudoperonospora cubensis*), powdery mildew (*Erysiphe cichoracearum* and *Sphaerotheca fuliginea*), anthracnose (*Colletotrichum lagenarium*), target leaf spot (*Corynespora cassiicola*) and gummy stem blight (*Didymella bryoniae*), as well as the bacterial disease angular leaf spot (*Pseudomonas lachrymans*). Anthracnose also causes symptoms on fruits. Good air circulation, for example through trellising, reduces the incidence of these diseases to some extent. Spraying of systemic fungicides such as benomyl (Benlate) or metalaxyl (Ridomil) can reduce spread; they can be alternated with broad spectrum fungicides such as copper oxychloride (Vitigran Blue) or mancozeb (Dithane). Other wilting in cucumber may be caused by soilborne Fusarium wilt (*Fusarium*

oxysporum f. sp. *cucumerinum*), or bacterial wilt (*Erwinia tracheiphila*), which is spread by cucumber beetles. In protected cultivation in temperate countries, especially Japan and Korea, grafting of cucumber on *Cucurbita ficifolia* Bouché or *Cucurbita maxima* Duchesne × *Cucurbita moschata* Duchesne rootstock is often practised to avoid soilborne diseases such as root rot caused by the fungi *Phomopsis sclerotioides* and *Fusarium oxysporum*; no experience with grafting in tropical Africa has been reported. Cucumber is susceptible to damping off, resulting in seedling death soon after emergence; it occurs more often when the soil is poorly drained, and can be caused by several fungi, e.g. *Pythium* spp. or *Phytophthora* spp., some of which can also cause root rot in older plants.

Fruit damage can be caused by scab (*Cladosporium cucumerinum*), a fungus that also attacks the leaves of susceptible cultivars, by bacterial soft rot (*Erwinia*), phytophthora fruit rot (*Phytophthora capsici*) and belly rot (*Rhizoctonia solani*). Resistance to scab is widely available; to prevent soft rot and other rotting of fruits, fruits should be handled with care especially during harvest to prevent damage as much as possible. Wounds on fruits are often the starting points of infection. Belly rot is soilborne and infects the fruits at the place where they touch the soil; preventing contact for example through the use of mulch or trellis systems can prevent this disease. Other fungal diseases observed in tropical Africa (Côte d'Ivoire) are *Alternaria* sp., *Cercospora citrullina*, *Choanephora cucurbitarum*, *Myrothecium roridum*, *Oidium tabaci* and *Sclerotium rolfsii*.

Commonly found viruses that can cause considerable yield losses in cucumber in the tropics are the aphid-borne cucumber mosaic virus (CMV), zucchini yellow mosaic virus (ZYMV), and papaya ringspot virus (PRSV), and a range of whitefly transmitted viruses that cause yellowing, such as cucumber vein yellowing virus (CVYV) and cucumber yellows virus (CYV). Another important virus is cucumber green mottle mosaic virus (CGMMV), which is highly seed transmitted. Special care must be taken not to grow seeds produced on infected plants; CGMMV can be easily spread mechanically, but it is unknown whether there is an insect or other vector.

Root-knot nematodes (*Meloidogyne* spp.) can severely affect plant growth resulting in stunting or wilting, thereby reducing yields.

A general recommendation is to grow cucumber only on sites where no other cucurbits have been grown for a number of years, to prevent soilborne diseases. Several of the diseases mentioned, such as angular leaf spot, scab, anthracnose, and phytophthora can be seedborne. Use of disease free seed or seed treated with chemicals can prevent early disease infection or insect attack and will reduce risk levels considerably. For most leaf diseases and viruses, resistant cultivars are available; using the relevant ones is a good way to minimize problems.

Aphids, whitefly and thrips are insects that can cause major problems, mainly because they act as vectors for viruses or diseases. General insect damage may be caused by beetles, leaf miners and leaf hoppers. The melon worm or pyralid moth (*Diaphania hyalinata*) and red spider mites (*Tetranychus* spp.) may cause much damage to the leaves, and fruit flies (*Dacus cucurbitae*) may cause fruit rotting. Non-bitter cultivars are more susceptible to damage by spider mites than bitter ones. The use of natural insect enemies is a more environmentally friendly method than spraying chemicals against pests, but until now it has mainly or exclusively been practised in protected cultivation of cucumber.

Harvesting Cucumber fruits for fresh consumption are harvested before they are fully mature; depending on the type this can be 1–2 weeks after flowering. The moment of first harvest is 40–60 days after sowing, depending on climate and cultivar. Harvesting is done every other day to every few days. For pickling types, immature fruits of several stages are harvested. Cucumber fruits for the fresh market are harvested by hand, but pickling types are also harvested mechanically all in a single harvest, especially on the large fields in the United States. For seed production, the fruits are allowed to mature on the plant.

Yield In 2002 average world yield for cucumber reached 18 t/ha, but the range is very wide. For Africa few data are available; estimates for DR Congo and Ghana are 4 and 10 t/ha respectively. In tropical Asia, countries such as Thailand, Indonesia and India have an estimated average yield of just below 10 t/ha. Hybrid cultivars in Thailand yield over 100 t/ha. The European Union as a whole produces an average of 90 t/ha, but under protected conditions in greenhouses this can be even higher, mainly because the crop's life cycle is extended considerably.

Handling after harvest Cucumber fruits

should be treated with care as they are sensitive to transportation damage. The maximum storage period is about 14 days at 13°C with a relative humidity of 95%. Below 10°C, chilling injury may occur and above 16°C fruits rapidly become yellow. Waxing or packaging in plastic film reduces moisture loss. In tropical countries, fruits will usually keep an acceptable marketable quality for around 5 days unless they are stored under cool conditions. After that they become soft and lose their crispy texture, and they can become yellowish.

Genetic resources Important germplasm collections are available in the Czech Republic (Breeding Station, Kvetoslavov), Germany (Institute for Plant Cultivation and Plant Breeding, Braunschweig), India (Kerala Agricultural University, Trichur), the Netherlands (Centre for Genetic Resources, Wageningen), the Philippines (Institute for Plant Breeding, Los Baños), Turkey (AARIR, Menemen, Izmir), Russian Federation (N.I. Vavilov Institute of Plant Industry, St Petersburg), United States (NCRPIS, Iowa State University, Ames; NSSL, USDA-ARS Colorado State University, Colorado).

Breeding Genetically, cucumber is one of the best known vegetable species and a great deal of work on breeding has been done. The first hybrid, the slicer 'Burpee Hybrid', was released in 1945. Gynoecious sex expression was found in a Korean cultivar. Since then, the development of hybrid, gynoecious and parthenocarpic cultivars has led to extremely high yields, especially in cucumber for fresh consumption cultivated in greenhouses. Breeding of disease- and pest-resistant cultivars, combined with better cultivation practices, has led to more than threefold increases in the yield of pickling cucumber over the past 60 years.

For tropical Africa, breeding work should aim at producing suitable cultivars for hot and humid conditions, with the necessary disease tolerances. The French company Technisem focuses on breeding for the tropics, mainly for West Africa, with experimental stations in e.g. Senegal, Mali, Benin and Cameroon under the name Tropicasem. For cucumber, the common open-pollinated slicer cultivars are sold, as well as improved hybrids in slicer, Beit Alpha, and pickling cucumber types. Depending on type preference, climate and disease problems, various options are available. The F_1 hybrid 'Tokyo' (slicer) is popular in West Africa. It tolerates hot and humid conditions, and has tolerance to downy mildew and CMV. Another, also heat tolerant, gynoecious hybrid is 'Olympic', which in addition to downy mildew and CMV has tolerance to powdery mildew and angular leaf spot. The pickling cucumber hybrid 'Antilla' is tolerant to heat, as well as to anthracnose, downy and powdery mildew. 'Arizona F_1' is a less heat tolerant pickler, but adds angular leaf spot and CMV tolerance. The Beit Alpha type 'F_1 Basma' has tolerance to both mildews, and to CMV and WMV viruses. The hybrid 'Excel' has a less vigorous plant and is parthenocarpic; it is especially suited for greenhouse growing.

Cucumber cultivars from East-West Seed Company, developed in South-East Asia, are also adapted to hot and humid conditions. Available cultivars for Africa in the slicer type are the F_1 hybrids 'Kande' and 'Kosey', which have strong vigour and tolerance to downy mildew; 'Kosey' has tolerance to ZYMV and PRSV.

Studies have shown that the genetic base within cultivated cucumber is rather narrow. Genebank accessions from various locations are however found to be genetically diverse, and often different from the commercial germplasm. More use of this material, as well as hybridization with related wild taxa might be promising to obtain new desirable characteristics. Combinations with *Cucumis sativus* var. *hardwickii* are made to increase branching and fruit set, especially in pickling cucumber cultivars. Interspecific crosses with *Cucumis hystrix* Chakrav. ($2n = 24$) have been attempted for quite some time. *Cucumis hystrix* is rather similar to cucumber and especially interesting because of its resistance to nematodes. After embryo rescue techniques and chromosome doubling, an amphidiploid ($2n = 38$) was obtained, which is now being further developed to try to obtain lines directly crossable with *Cucumis sativus*.

Prospects Cucumber is quite important in tropical Africa, and is becoming increasingly so because it is an easy to prepare vegetable and suited for sale in supermarkets and the big city markets. Moreover, cultivars are becoming available that are more adapted to the climatic conditions prevailing in tropical Africa, and that also include the relevant disease tolerances.

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CUCUMIS ZEYHERI Sond.

Protologue Harv. & Sond., Fl. Cap. 2: 496 (1862).

Family Cucurbitaceae

Chromosome number $2n = 24, 48$

Synonyms *Cucumis prophetarum* L. subsp. *zeyheri* (Sond.) C.Jeffrey (1962).

Vernacular names Wild cucumber (En).

Origin and geographic distribution *Cucumis zeyheri* is restricted to the eastern part of southern Africa: Zambia, Zimbabwe, Mozambique and South Africa.

Uses The non-bitter fruits are eaten raw or pickled. The bitter fruits are used as a (drastic) purgative.

Properties There is no information on the nutritive value of the fruits, but probably it is comparable to cucumber.

The fruits of *Cucumis zeyheri* contain cucurbitacins B and D. Cucurbitacins, which are known from many *Cucurbitaceae* and various other plant species, exhibit cytotoxicity (including antitumour activity), anti-inflammatory and analgesic activities.

Botany Perennial, monoecious, prostrate or rarely scandent herb, with simple tendrils; roots fibrous, woody; stems up to 2 m long. Leaves alternate, simple; petiole 0.5–4 cm long; blade ovate (rarely ovate-triangular), 2.5–9 cm × 2–6 cm, deeply palmately 3–5-lobed, rarely unlobed, slightly cordate at base, lobes variable but mostly elliptical or narrowly elliptical, each 3–5-lobed. Flowers solitary, unisexual, regular, 5-merous; receptacle 2.5–4.5 mm long; sepals 1–4 mm long; petals 4.5–9 mm long, yellow; male flowers with pedicel 3–12(–22) mm long, stamens 3; female flowers with pedicel 3–12 mm long, ovary inferior, densely softly hairy. Fruit an oblong, ellipsoid or obovoid-ellipsoid berry, 3.5–5 cm × 2.5–3.5 cm, concolorous yellow when ripe, spines slender, up to 1.5 cm long; fruit stalk 2–5 cm long. Seeds elliptical in outline, 5–8.5 mm × 2–4.5 mm × 1.5–2 mm, whitish.

The genus *Cucumis* includes about 30 species, 4 of which are economically important: cucumber (*Cucumis sativus* L.), melon and snake cucumber (*Cucumis melo* L.), West Indian gherkin (*Cucumis anguria* L.) and horned melon (*Cucumis metuliferus* Naudin). *Cucumis zeyheri* belongs to the 'anguria' group of the subgenus *Melo*.

Ecology *Cucumis zeyheri* occurs in open woodland, in grassland and as a weed on cultivated ground at 300–1650 m altitude.

Management Fruits are collected from wild plants.

Genetic resources and breeding As *Cucumis zeyheri* is common, it is not threatened by genetic erosion. There are genebank accessions recorded in the Czech Republic, Spain, France and the United States. Fully fertile hybrids can be obtained from crosses of *Cucumis zeyheri* with *Cucumis anguria*, *Cucumis africanus* L.f. and *Cucumis myriocarpus* Naudin. Resistance to downy mildew (*Pseudoperonospora cubensis*) and scab (*Cladosporium cucumerinum*), both economically important pathogens of cucumber, has been found in *Cucumis zeyheri*.

Prospects As a vegetable *Cucumis zeyheri* will remain locally of some importance. As a source of disease resistance it may make an important contribution to breeding, especially of cucumber.

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CUCURBITA FICIFOLIA Bouché

Protologue Verh. Vereins Beförd. Gartenbaues Königl. Preuss. Staaten 12: 205 (1837).

Family Cucurbitaceae

Chromosome number $2n = 40$

Synonyms *Cucurbita melanosperma* A.Braun ex Gasp. (1847), *Pepo ficifolia* Britton (1925).

Vernacular names Fig-leaf gourd, Malabar gourd, black-seeded gourd (En). Courge de Siam, melon de Malabar (Fr). Abóbora chila, abóbora gila (Po). Mboga ya kimasai (Sw).

Origin and geographic distribution *Cucur-*

Cucurbita ficifolia – planted

bita ficifolia is a cultigen originating from highland regions of Latin America (from Mexico to Chile) where it is still widely cultivated. The first fruits to reach Europe apparently took a circuitous route from South America to the Malabar Coast of India along the much travelled trade routes in the 16th and 17th centuries, hence the vernacular names in English and French. Fig-leaf gourd occurs in tropical Africa in the highlands of Ethiopia, Kenya and Tanzania and is occasionally grown in Angola. In Asia it is grown in India, Japan, Korea and China and in the highlands of the Philippines.

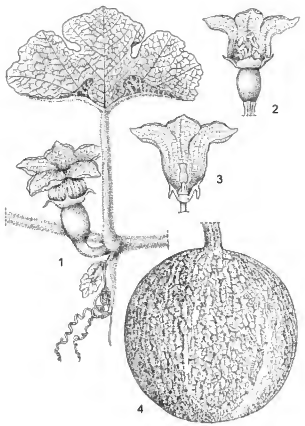
Uses Fig-leaf gourd is grown as a vegetable for the leaves and the immature fruits. In East Africa mainly the leaves are eaten. In Kenya, where it is known as 'kahurura' (Kikuyu), and in Tanzania, where the vegetable is known as 'boga la kimasai' (Swahili), the leaves are prepared in a mixture with maize, pulses, green bananas or Irish potato. Young fruits are occasionally eaten as a cooked vegetable like pumpkin, but in most places in Kenya and Tanzania the fruits are considered not edible. However, they are used to prepare an alcoholic drink. In Latin America and the Philippines tender young fruits are used like summer squash (*Cucurbita pepo* L.). The flesh of mature fruits is impregnated with sugar for preparation of a candy or jam, mature fruits are fermented for an alcoholic beverage, male flowers and buds are used in soups, stews and salads, and the raw or roasted seeds are eaten as a snack food. Also in Spain, the fruits are used for jam preparation. In Europe, fig-leaf gourd is also cultivated as an ornamental because of its decorative white-spotted dark green fruits. Fig-leaf gourd is used in temperate countries as a rootstock for greenhouse cucumber (western Europe, Korea, China, Japan) and for melon and watermelon (Korea, China, Japan). It gives the grafted crop increased cold tolerance and high resistance to soilborne pathogens and increases the resistance to *Pythium* and powdery mildew. Like several other cucurbits, fig-leaf gourd consumption by diabetic patients has a hypoglycaemic effect, making it an appropriate medicine against diabetes mellitus. The seed complete with the husk is ground into a flour that is made into an emulsion with water and taken as a vermifuge. A purgative should be taken afterwards to expel tapeworms or other parasites.

Production and international trade Fig-leaf gourd is of local importance in East Africa, but no production statistics are available.

Properties No data on the composition of *Cucurbita ficifolia* are reported, but it is probably similar to that of other cucurbits. The composition of pumpkin (*Cucurbita* spp.) leaves per 100 g edible portion is: water 89 g, energy 105 kJ (25 kcal), protein 4.0 g, fat 0.2 g, carbohydrate 2 g, fibre 2.4 g, Ca 475 mg, P 135 mg, Fe 0.8 mg, β-carotene 1.0 mg, thiamin 0.08 mg, riboflavin 0.06 mg, niacin 0.3 mg, ascorbic acid 80 mg. The composition of immature fruits is comparable to that of *Cucurbita pepo* (summer squash). The fruit pulp contains a proteolytic enzyme that has potential value in the food industry. The seeds are rich in protein and oil; the oil is made up mainly of oleic acid.
Hypoglycaemic activity of fruit extracts of *Cucurbita ficifolia* has been demonstrated in animal models (mice, rabbits) as well as in clinical tests with diabetic patients. The mechanism of the hypoglycaemic effect is still unknown.

Adulterations and substitutes Leaves and fruits of fig-leaf gourd can be replaced by musk pumpkin (*Cucurbita moschata* Duchesne), fruits also by summer squash (*Cucurbita pepo*) and roasted seed by those of any other *Cucurbita* species.

Description Short-lived perennial vine climbing by long, branched tendrils, herbaceous but becoming somewhat woody; taproot up to 2 m long, lateral roots forming a network slightly below the soil surface; stem with numerous long runners, smoothly 5-angled to rounded, prickly or spiny, often rooting at nodes. Leaves alternate, simple, without stipules; blade circular-ovate to nearly reniform in outline, sinuate to lobed with obtuse sinuses,



Cucurbita ficifolia – 1, part of stem with leaf and female flower; 2, female flower in longitudinal section; 3, male flower in longitudinal section; 4, fruit.
Source: PROSEA

18–25 cm in diameter, margins toothed to entire. Flowers solitary, unisexual, regular, 5-merous, up to 7.5 cm in diameter, yellow to pale orange; calyx and corolla campanulate with short tube; male flowers with short, thick and columnar androecium, filaments with trichomes more than 1 mm long; female flowers on short, ridged pedicels with inferior ovary. Fruit a large, globose to cylindrical berry 15–50 cm long, green with white stripes and blotches; rind smooth, hard; flesh of mature fruits white, coarse, tough, fibrous and rather dry, many-seeded; fruit stalk not or only slightly enlarged at apex. Seeds oblong-ellipsoid, flattened, 1.5–2.5 cm long, without a spongy epidermis, usually black, sometimes pale buff-coloured. Seedling with epigeal germination.

Other botanical information In the taxonomic literature, 3 characteristics are often mentioned to distinguish *Cucurbita ficifolia* from the other cultivated *Cucurbita* species: perennial growth habit, leaf shaped like a leaf of the fig (*Ficus carica* L.) and black seeds. Those characteristics can be misleading because *Cucurbita ficifolia* does not differ in longevity from the other squash species, the fig-leaf form also occurs in other species, and the seeds are not always black. Most diagnostic are the following characteristics: the presence of trichomes on the filaments in the male flowers, and the shape of the seeds (length-to-width ratio of 3:2, which is broader than in other cultivated *Cucurbita* species).
Local cultivars of fig-leaf gourd occur in East Africa. The main variation is in fruit size and the white and green spotting.

Growth and development Seeds germinate 5–7 days after sowing. The plants are extremely vigorous and form an extensive fibrous root system. The stems may reach a length of over 30 m. Under suitable conditions, the branching and trailing stems will grow indefinitely when they are permitted to root at the nodes touching the soil. However, fig-leaf gourd is usually grown as an annual. Flowering under short-day conditions starts 30–60 days after emergence of the seedling and is continuous. The ratio of male to female flowers is about 20:1, but is influenced by growing conditions; long days and high temperatures favour the male sex expression. Production of sticky pollen is abundant. Anthesis and pollination take place early in the morning. Insects, mainly bees, effect pollination. Solitary plants also set a fair number of fruits; 1–2 fruits per stem develop. The fruit matures 30–40 days after pollination. The harvest period of young leaves extends from 2–6 months after sowing.

Ecology In the tropics it is grown at altitudes above 1000 m, in the mountains of Latin America from 1000–3000 m. It is more cold resistant than any other *Cucurbita* species, but night frost kills the plant. Fig-leaf gourd requires a short or shortening photoperiod for flowering. In temperate areas it is grown in the summer, starting flowering with decreasing daylength. Daylength-neutral cultivars have been reported. Fig-leaf gourd prefers fertile, well-drained soils with a pH range of 6.5–7.5.

Propagation and planting Propagation is by seed, although fig-leaf gourd may be easily vegetatively propagated because of the root development from the nodes. The weight of 1000 seeds is 180–250 g. For seed germination, soil temperatures should be above 15°C; the germination percentage is highest at 35°C. Stored seeds are hard-coated, and scouring or soaking in water for some hours is recommended. Seed are sown in flats, flat ridges or

on mounds or hills. Seeds are planted 2–5 cm deep, depending on the soil texture. A practical planting distance is 2 m × 2 m giving a plant population of 2500 plants/ha: the seed requirement is 2–3 kg/ha. Because of the creeping plant habit, the optimal planting density is flexible, varying from 1000–6000 plants/ha. With a dense planting, the soil is covered sooner and weeds are suppressed. Fig-leaf gourd is usually grown on small acreages, even as a single plant in home gardens, against trellises and walls or trees. It is occasionally grown as an intercrop in maize or sorghum.

Management Fig-leaf gourd responds well to applications of up to 30 t/ha of organic manure during site preparation; additional application of inorganic fertilizers (110 kg/ha N, 40 kg/ha P, 90 kg/ha K) is beneficial. Under dry conditions irrigation should be applied, e.g. weekly 50 mm.

Diseases and pests Fig-leaf gourd is strongly resistant to pests and diseases, more so than other *Cucurbita* species. Diseases observed in India and the Philippines are leaf and stem rot (*Alternaria* spp.), watery soft rot (*Sclerotinia sclerotiorum*), leaf and stem spot (*Stemphylium* spp.), bacterial leaf spot (*Xanthomonas cucurbitae*), powdery mildew (*Erysiphe chicoracearum*) and virus diseases (cucumber, melon, squash, watermelon mosaic viruses). Usually no control measures are taken. For virus diseases, it is important to use virus-free seed, to remove infected plants early, and to control the vectors. The major insect pests reported are yellow beetle (*Aulocophora similis*), whitefly (*Bemisia tabaci*) and aphids (*Aphis* spp.), all of which are potential vectors of viruses.

Harvesting Continuous weekly picking of young leaves may take place from 6 weeks after emergence of the seedling to the end of the vegetative growth period. The harvest of immature fruits by cutting the fruit stalk occurs in many rounds, from 2 months to the end of the crop. For home consumption, young leaves and shoots are picked when needed. Seeds are extracted from mature fruits for future planting.

Yield The fruit yield largely depends on cultivar and growing conditions. Up to 10 mature fruits may be harvested per plant. The weight of young fruits is about 1 kg, mature fruits weigh 3–8 kg. Per ha, an estimated quantity of 20 t of leaves or 40 t of young fruits might be harvested. Regular picking of leaves will decrease the fruit yield. Seed yield is about 500 kg/ha.

Handling after harvest Leaves have to be consumed within two days after harvesting, young fruits can be kept for some weeks. Cuts and bruises of mature fruits heal by suberization within a week. Mature fruits can be kept for a long period in a dry place at room temperature, in temperate areas for even longer than a year. They become sweeter with storage.

Genetic resources *Cucurbita ficifolia* is the least variable of the cultivated *Cucurbita* species. It is represented in the *Cucurbita* collections of many institutions, in particular in Central and South America (CATIE, Turrialba, Costa Rica: San Carlos University, Guatemala; INIFAP, Celaya, Mexico). It is also found in germplasm collections in the United States (National Seed Storage Laboratory, Fort Collins, Colorado; Southern Regional Plant Introduction Station, Georgia), Russia (Vavilov Institute of Plant Industry, St Petersburg) and the Philippines (Institute of Plant Breeding, Los Baños). These collections, however, are not representative of its full geographic distribution.

Breeding *Cucurbita ficifolia* is naturally cross-pollinated but self-compatible, inbreeding causing little loss of vigour. No breeding programme has been reported, although distinct local cultivars are known, and international seed companies trade cultivars for rootstock. Fig-leaf gourd has been tried frequently as genitor for disease- and cold-resistance to pumpkins (*Cucurbita maxima* Duchesne ex Lam., *Cucurbita moschata*) and squashes (*Cucurbita pepo*), but it shows considerable isoenzymatic and chromosomal differences compared with all other taxa of the genus. F_1 plants have only been obtained by embryo rescue and no further progress has been reported.

Prospects Fig-leaf gourd has potential as a fresh leaf and fruit vegetable in East Africa and southern Africa in highland regions. The fruit quality should be improved by breeding. It may become a rootstock for cucumber, melon and other cucurbits.

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Sources of illustration Roxas, V.P., 1993.

Authors G.J.H. Grubben

Based on PROSEA 8: Vegetables.

CUCURBITA MAXIMA Duchesne

Protologue Essai Hist. Nat. Courges: 7, 12 (1786).

Family Cucurbitaceae

Chromosome number $2n = 40$

Vernacular names Pumpkin, winter squash (En). Potiron, courge d'hiver, courge turban (Fr). Abóbora-menina, abóbora-moranga (Po). Mtango (Sw).

Origin and geographic distribution *Cucurbita maxima* originates from temperate South America. *Cucurbita andreana* Naudin is considered the wild progenitor; this species is native to warmer temperate zones in South America as well as humid lowland regions of Bolivia. Seeds of *Cucurbita maxima* excavated in Peru have been dated at 1800 BC. After 1492, when Columbus arrived in the Americas, it spread all over the tropics and subtropics, as well as temperate areas with warm summers. *Cucurbita maxima* has been reported from many countries in tropical Africa and probably occurs in all countries. It is most important in the cooler parts of southern Africa and the Sahel region, less important in more humid West and East Africa, where *Cucurbita moschata* Duchesne is more common.

Uses The mature fruits, leaves, flowers and seeds of *Cucurbita maxima* are used as vegetables. Most crops are grown for the fruits, but the leaves are locally important too. The leaves are regarded as a bit coarse and of lesser quality than those of *Cucurbita moschata*, although this disappears in cooking. They are used fresh and in some locations dried for use during the off-season. The mature fruit is peeled, cut into pieces and cooked until soft. In Zimbabwe it is made into a popular porridge. In Cameroon, Nigeria and other western African countries, seeds are commonly roasted and salted, or ground into a thick paste that is mixed with vegetables in cooking. They are exported to the Middle East where they are a popular snack. The seed is rich in oil, which is sometimes extracted for kitchen use. The big, yellow-orange fruits of certain cultivars are used for decoration. Dried fruit-shells can be used for making bowls.

Cucurbita maxima – planted

In North America, great healing qualities for skin problems such as sores and ulcers are attributed to pumpkin seed oil. Traditionally, American Indians use the seeds to treat intestinal infections and kidney problems and to expel tapeworms; the flowers are used topically to soothe minor injuries. In southern Europe the seeds are also used as an anthelmintic. In India, a paste of the fruit stalks is used to heal boils and earache.

Production and international trade World production of pumpkin and squash (all *Cucurbita* species taken together) in 2001 was estimated at 16.4 million t from 1.2 million ha, and production in Africa at 1.8 million t from 140,000 ha. China and India are the largest producers with nearly 4 million t each, followed by Ukraine (900,000 t) and Egypt (360,000 t). In tropical Africa, a production of 205,000 t has been recorded for Rwanda, 120,000 t for Cameroon and 70,000 t for Sudan. The international demand for pumpkin seeds, especially from *Cucurbita maxima*, is significant but official statistics are not available. This demand is mainly from Arab countries, where roasted seeds are a popular snack, but recently also from Western countries, where the seed oil is now in demand for the pharmaceutical and cosmetics industry. At national level, the leaves, fruits and often also seeds are found on local markets.

Properties The composition of pumpkin fruits per 100 g edible portion (67% of purchased, flesh only, seeds removed, peeled thickly) is: water 95.0 g, energy 55 kJ (13 kcal), protein 0.7 g, fat 0.2 g, carbohydrate 2.2 g, fibre 1.0 g, Ca 29 mg, P 19 mg, Fe 0.4 mg, β-carotene 450 µg, thiamin 0.16 mg, riboflavin trace, nia-

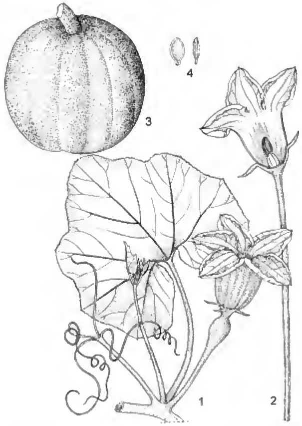
cin 0.1 mg, folate 10 μg, ascorbic acid 14 mg (Holland, B., Unwin, I.D. & Buss, D.H., 1991). The composition of pumpkin leaves per 100 g is: water 89.2 g, energy 113 kJ (27 kcal), protein 4.0 g, fat 0.2 g, carbohydrate 4.4 g, fibre 2.4 g, Ca 477 mg, P 136 mg, Fe 0.8 mg, β-carotene 3600 μg, thiamin 0.06 mg, riboflavin 0.32 mg, ascorbic acid 80 mg. The composition of pumpkin seeds (without shell) per 100 g is given as: water 5.5 g, energy 2331 kJ (555 kcal), protein 23.4 g, fat 46.2 g, carbohydrate 21.5 g, fibre 2.2 g, Ca 57 mg, P 900 mg, Fe 2.8 mg, thiamin 0.15 mg, niacin 1.4 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). Pumpkin seeds also contain considerable amounts of vitamin E.

All cucurbits contain triterpene glycosides called cucurbitacins. These compounds are present in all plant parts in different concentrations. If concentrated in the edible parts, they cause a bitter taste. In *Cucurbita maxima* they are present in small amounts only, unlike *Cucurbita andreana*, which may contain considerable amounts. The antigenotoxic compound spinasterol was isolated from *Cucurbita maxima* flowers. In in-vivo tests with mice it decreased the mutagenicity of tetracycline by 65% at a dosage of 100 mg/kg. Crude ethanolic extracts of seeds showed strong antimalarial activity, reducing by 50% the levels of parasitaemia in *Plasmodium berghei*-infected mice at an oral dosage of 500 mg/kg. Seeds and vascular exudates of *Cucurbita maxima* contain proteinase inhibitors that prevent proteolytic activity of trypsin or chymotrypsin. One of these proteins, *Cucurbita maxima* trypsin inhibitor V (CMTI-V), is also a specific inhibitor of human blood coagulation factor XIIa.

Adulterations and substitutes The fruits, leaves and seeds of *Cucurbita moschata* can be used as a substitute for *Cucurbita maxima*. Egusi (*Citrullus lanatus* (Thunb.) Matsum. & Nakai and *Cucumeropsis mannii* Naudin) are substitutes for pumpkin seeds.

Description Annual, scandent herb, climbing by lateral, 2–5-branched tendrils, strongly branched; stems rounded, long running, softly pubescent, often rooting at nodes. Leaves alternate, simple, without stipules; petiole (5–)10–20 cm long; blade usually reniform, not lobed to shallowly 5–7-lobed, 7–25(–30) cm in diameter, deeply cordate at base, margins finely toothed, softly hairy, occasionally with white blotches, 3-veined from the base. Flowers solitary, unisexual, regular, 5-merous, large, 10–20 cm in diameter, lemon yellow to orange-yellow; sepals free, subulate to linear, 0.5–2 cm long; corolla campanulate, with widely spreading lobes; male flowers long-pedicelled (up to 23 cm), with 3 stamens, filaments free, anthers connivent into a long twisted body; female flowers shortly pedicelled (up to 5.5 cm), with inferior, ellipsoid, 1-celled ovary, style thick, stigmas 3–5, 2-lobed. Fruit a large, globose to ovoid or obovoid berry, weighing up to 50 kg, with a wide range of colours; flesh yellow-orange, many-seeded; fruit stalk cylindrical, not enlarged at apex. Seeds obovoid, flattened, 1.5–2.5 cm × 1–1.5 cm, white to pale brown, surface smooth to somewhat rough, margin prominent. Seedling with epigeal germination; hypocotyl 3–3.5 cm long; cotyledons elliptical, 2.5–4 cm long, cuneate at base, obtuse at apex, entire.

Other botanical information It is often not easy to distinguish *Cucurbita maxima* plants or fruits from the related *Cucurbita moschata* and *Cucurbita pepo* L.. The plant habit is similar and the fruit shape and size are variable. Distinction is easiest by observing differences of the fruit stalk, stems and leaves. *Cucurbita maxima* has a soft, rounded fruit



Cucurbita maxima – 1, stem fragment with female flower; 2, male flower in longitudinal section; 3, fruit; 4, seeds.
Redrawn and adapted by Iskak Syamsudin

stalk not enlarged at the apex, soft, rounded stems and soft, usually unlobed leaves. *Cucurbita moschata* has a hard, smoothly angled fruit stalk widened at the apex, hard, smoothly grooved stems and soft, moderately lobed leaves. *Cucurbita pepo* has an angular fruit stalk sometimes slightly widened at the apex, hard, angular, grooved, prickly stems and palmately lobed, often deeply cut and prickly leaves.

Cucurbita andreana, a species related to *Cucurbita maxima* and sometimes considered a subspecies of the latter, occurs wild in Argentina and Bolivia; it hybridizes readily with *Cucurbita maxima*. It may be the ancestor of *Cucurbita maxima*.

There are numerous cultivars of *Cucurbita maxima* in Western countries. A classification into cultivar-groups has been proposed, but it is of little relevance for tropical Africa. Some well known cultivars imported in East and southern Africa are 'Turban', 'Mammoth' and 'Flat Boer'.

Growth and development Seed germinates 5–7 days after sowing. The plants form an extensive fibrous root system. The growth habit is indeterminate; under suitable conditions, the trailing stems continue to grow indefinitely when they are permitted to root at the nodes. The stems may reach a length of more than 20 m, but they are usually no longer than about 5 m. Bushy cultivars with short internodes and semi-erect stems also exist. Flowering starts 35–60 days after germination and is more or less continuous. The ratio of male to female flowers is about 20:1. This ratio is influenced by the growing conditions, long days and high temperatures favouring male sex expression. Production of the sticky pollen is abundant. Anthesis and pollination take place early in the morning. Insects, mainly bees, effect pollination, so the flowers are predominantly cross-pollinated. The fruits mature 30–40 days after pollination. One or two fruits develop per stem. The fruit-harvesting period extends from 2–6 months after sowing.

Ecology *Cucurbita maxima* pumpkins are grown in the tropics from the lowlands up to 2000 m altitude. Optimum mean daily temperatures for growth are 18–27°C. *Cucurbita maxima* is more tolerant to low temperatures than *Cucurbita moschata*, but less tolerant to high temperatures. It is almost insensitive to photoperiod and tolerates some shading. *Cucurbita maxima* is rather drought tolerant, requiring relatively little water, and is sensitive to frost and waterlogging. Pumpkins can be produced year round in frost-free areas, although excessive humidity during the rainy season stimulates the development of fungal and bacterial diseases causing leaf decay, wilting and fruit rot. Pumpkins are not very demanding with respect to soil. They can be cultivated on almost any well-drained soil with a neutral or slightly acid reaction (pH 5.5–6.8). They will grow on reasonably fertile soil, but do best on soils rich in organic matter.

Propagation and planting *Cucurbita maxima* is grown from seed. As it roots at the nodes it can be grown from cuttings, but this is only done for research purposes. Seed of improved, mostly imported, cultivars is rarely used in tropical Africa, where most farmers produce their own seed. It is important to take only top quality fruits from healthy plants for this purpose. For seed extraction, mature fruits are split and fermented, then the seed is collected, washed, cleaned and dried. Farmers sow in small hills on flat land or in raised beds, 2–4 seeds per hill. Seeds can be sown in containers and the seedlings transplanted into the field when they are about 10 cm tall, but direct seeding is generally practised in most African countries.

Pumpkin is often grown in home gardens. It grows well on organic matter and is often encountered on refuse heaps, on termite hills and on fertile patches in the field and around homesteads. In urban areas, it is planted in backyard gardens mixed with maize; in the field, it is usually intercropped with cereals such as maize and sorghum, or with groundnut. Sole cropping is common for commercial production, e.g. when grown for the seeds. A common planting distance is 2 m × 2 m, giving a plant population of 2500 plants/ha. The 1000-seed weight is about 200 g; the seed requirement is 2–3 kg/ha. Many farmers use much more seed, up to 7 kg/ha. Because of the branching and creeping plant habit, the optimal planting density is flexible, varying from 600–4000 plants/ha; the number of plants per hill is 1–4. With a dense planting, the soil will be covered and weeds will be suppressed more quickly.

Management The crop responds well to farm manure and to side dressings of liquid manure. Depending on soil fertility, the following application is recommended: 50–100 kg/ha N, 20–40 kg/ha P and 40–80 kg/ha K during the vegetative phase. Some of the minerals can be applied as a top dressing of NPK 10–10–10, e.g. 50 kg/ha or 20 g per plant at the first fruit

setting. Irrigation should be applied under dry conditions, e.g. weekly 50 mm.

Diseases and pests Many diseases and pests attack *Cucurbita maxima*; they are the same as for *Cucurbita moschata*, but are possibly more serious under humid conditions. Only the most serious ones will be mentioned here. Downy mildew (*Pseudoperonospora cubensis*) often becomes a devastating disease under conditions of high air humidity. It starts on the older leaves with pale green angular spots, bounded by leaf veins. The lower surface becomes covered with a faint, purplish layer and the entire leaf dies. Control is by wide spacing, good drainage and aeration and by crop rotation. Powdery mildew (*Erysiphe cichoracearum*) may be severe under low humidity. The upper side of affected leaves is covered with white powdery fungus growth; the leaves become yellowish and dry out. Alternaria leaf spot or leaf blight (*Alternaria cucumerina*) is a fungal disease that defoliates and kills the plants within weeks. This fungus also causes fruit rot. The symptoms, small round whitish necrotic spots, later with concentric circles, appear on the oldest leaves; the leaves turn grey or yellow and dry out. The use of healthy seed, removal of plant debris and crop rotation may provide some control. Gummy stem blight or gummy canker (*Didymella bryoniae*, anamorph: *Phoma cucurbitacearum*) is a serious cause of crop losses everywhere. First the nodes with nearly ripe fruits are attacked; they become oily-green and sap exudes forming drops of gum, while the stems beyond the affected area wilt. This fungus also causes seedling death, fruit stalk canker and fruit rot. Control is by using healthy seed and protective fungicides, e.g. mancozeb, and by crop rotation. No cultivar resistance has been reported. Fusarium wilt (*Fusarium oxysporum*) causes yellowing of the leaves followed by wilting of stems or the whole plant. It can be controlled by using healthy seed, removing debris, crop rotation and avoiding excessive nitrogen fertilization. Anthracnose (*Colletotrichum lagenarium*) is a destructive disease worldwide. It causes defoliation and lesions on the fruits. All diseases mentioned may be seedborne; it is therefore important to use only seeds from healthy plants. Other diseases are scab (*Cladosporium cucumerinum*), causing small spots on all plant parts, and Choanephora wet rot (*Choanephora cucurbitarum*), causing fruit rot. Of the many viruses reported on *Cucurbita maxima* the most important ones are cucumber mosaic virus (CMV), papaya ring spot virus (PRSV-W), squash leaf curl virus (SLCV), watermelon mosaic virus (WMV-2) and zucchini yellow mosaic virus (ZYMV). These viruses often occur in combination. They are spread by mechanical infection and insects (mainly aphids, whitefly and thrips), and probably some by seed.

Insect pests are seldom serious. Nevertheless it is important to keep aphids, whitefly and thrips under control to avoid spreading virus diseases. Whitefly (e.g. *Bemisia* spp.) may cause damage. Leaf-feeding *Epilachna* beetles may be harmful on young plants. A ladybird (*Henosepilachna elaterii*) is reported as a major pest on pumpkins in Sudan. Spider mites (*Tetranychus* spp.) may also cause damage.

Harvesting Pumpkin fruits are picked when nearly or fully mature, 4–6 weeks after flowering, and are harvested in several rounds until the crop stops producing, 90–120 days after planting. Some African farmers leave the fruits in the field until they collect the whole crop. For leaf consumption, usually the third and fourth leaves from the tip are harvested; the first and second leaf are left to continue growing. Sometimes the tips are removed to promote branching. Occasionally flowers and young immature fruits are harvested for consumption.

Yield The yield largely depends on cultivar and growing conditions. The number of mature fruits harvested per plant is low, and the weight of individual fruits, mainly depending on cultivar, varies widely from 1–50 kg. Under extensive low input management, the yield is low, around 5 t/ha. With good care, a yield of 15 t/ha is reasonable, and with improved cultivars a yield of 30 t/ha is possible. Excessive picking of the young leaves and shoots reduces fruit yield. Seed yield is variable, possibly 300–500 kg/ha. If grown for seed, isolation between fields of different *Cucurbita* species is recommended, not only for reasons of purity but also to obtain maximum yields, because pollen of other species may cause reduced fruit set or parthenocarpic fruits.

Handling after harvest Leaves are consumed fresh or in dried form. Before cooking the main veins of the leaves are removed. For drying, the leaves are cut into small pieces and spread in the open to dry for 1–2 days depending on weather conditions. The leaves are stored in containers. Healthy fruits can be stored for several months on slatted shelves with good ventilation. The flesh can be dried in

strips for later use in soups and stews. Seeds are often extracted as the fruits are consumed; some are stored for future planting, others are used as food. When a crop is grown for its seed the fruit is a by-product. Seeds are offered either in their shell or after shelling, shelled seeds commanding considerably higher prices. The shelling process is tedious when done by hand; mechanized shelling is now carried out in several countries, e.g. Nigeria and Sudan. Care should be taken not to break the seeds and not to remove the shell too long before sale at the market. Shelled seeds are more likely to be affected by storage pathogens, especially *Aspergillus* species, which release poisonous aflatoxins under warm, humid conditions.

Genetic resources *Cucurbita* species are well represented in the cucurbit germplasm collections of many institutions all over the world. However, little attention has been paid to germplasm of African types. The National Seed Storage Laboratory (NSSL), Fort Collins, Colorado, United States, and the Vavilov Institute of Plant Industry (VIR), Petersburg, Russia maintain important base collections. With the introduction of improved cultivars, ancient landraces are in danger of disappearing and collection of germplasm of African landraces deserves priority.

Breeding *Cucurbita maxima* is cross-pollinated but self-compatible, inbreeding causing little loss of vigour. A considerable degree of heterosis of inbred lines has been observed. Hand pollination of the large flowers is easy. Seed companies are less interested in open-pollinated cultivars, because farmers can easily produce their own seed. Western seed companies have commercialized many F_1-hybrids. A Japanese seed company has developed 'Shintoza', an interspecific hybrid of *Cucurbita maxima* and *Cucurbita moschata*, which combines high vigour and resistances to soilborne diseases and nematodes. It is used as rootstock for cucumber instead of chemical soil disinfection. Breeding work in the tropics is rare and little breeding work has been reported from tropical Africa.

Prospects As a multipurpose vegetable *Cucurbita maxima* makes a valuable contribution to the food resources of Africa. Yield levels can be increased considerably as cultural practices are extensive and as almost no breeding for yield, disease or pest resistance and quality has been done. Besides development of improved cultivars for the fruits, attention should be paid to the potential of the leaves and seed. Hybrid cultivars with virus resistance genes have considerable potential.

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Authors F. Chigumira Ngwerume & G.J.H. Grubben

CUCURBITA MOSCHATA Duchesne

Protologue Essai Hist. Nat. Courges: 7, 15–16 (1786).

Family Cucurbitaceae

Chromosome number $2n = 40$

Synonyms *Cucurbita pepo* L. var. *moschata* Lam. (1786).

Vernacular names Musk pumpkin, pumpkin, musky gourd, winter squash (En). Courge musquée, giraumon (Fr). Abóbora moscata, abóbora almiscarada (Po). Mboga (Sw).

Origin and geographic distribution The genus *Cucurbita* originates from Central and South America. The wild ancestor of *Cucurbita moschata* is still unknown, but recent investigations of the phylogenetic relationships among wild and domesticated *Cucurbita* taxa, mainly based on DNA data, suggest that it will probably be found in lowland northern South America. Archaeological evidence for the association of cultivated *Cucurbita* with man dates back to 5000 years BC. After the discovery of the new world, the cultivated cucurbits were introduced into the old world. Since the 17th century they have spread all over the tropics and subtropics. *Cucurbita moschata* is the most heat tolerant *Cucurbita* species and the most common in tropical Africa. It is most probably

Cucurbita moschata – planted

cultivated in all countries of tropical Africa, but it is more important in southern Africa than in East and West Africa.

Uses Musk pumpkin is a multipurpose fruit and leaf vegetable, but the flowers are consumed too. The most common product, popular in most African countries, is the cooked mature fruit. The fruit is also popular for making pumpkin pie and in South-East Asia it is made into sweets and desserts, e.g. steamed fruit flesh with grated coconut and sugar, and into crisps made by frying steamed fruit flesh mixed with cassava flour. In Zambia the ripe fruit flesh is dried for longer preservation.

Especially in southern Africa the leaves play an important role as a leading leaf vegetable during the rainy season. Pumpkin leaves are prepared by first removing the main veins and tendrils, after which they are cut into narrow slices and cooked. Other ingredients, like peanut butter, cooking oil, onions, tomato and spices, are added. In Zambia, 40% of the households use pumpkin leaves as relish daily during the rainy season. In Mashonaland-West and other parts of Zimbabwe pumpkin leaves are the most popular leaf vegetable.

In Cameroon and other parts of Central and West Africa *Cucurbita moschata* is principally grown for the ripe seeds. These are first roasted, the shells removed, and squashed into a paste and consumed with the main dish. Roasted seeds with or without shells are also salted and eaten as a snack. The potential of the seeds as a source of vegetable fat has not been fully exploited. The seed oil is edible and used as fuel.

Cucurbita moschata has several medicinal applications in Thailand and China. Crushed fresh seeds are used as an anthelmintic, and are also applied to skin infections and inflammations.

Production and international trade In FAO statistics, world production of pumpkin and squash (all *Cucurbita* species taken together) in 2000 is indicated as 16.0 million t from 1.3 million ha; African production is estimated at 1.8 million t from 140,000 ha, corresponding with an average yield of 12.8 t/ha. These data are very incomplete, reflecting the production from only 16 African countries, of which 9 in tropical Africa. No detailed information per species or country is available. International trade of pumpkin leaves, fruits and seed is very minor or nonexistent, but at national level the leaves and fruits and often the seeds are important products on the local markets.

Properties The composition of pumpkin fruits per 100 g edible portion (67% of purchased, flesh only, seeds removed, peeled thickly) is as follows: water 95.0 g, energy 35 kJ (13 kcal), protein 0.7 g, fat 0.2 g, carbohydrate 2.2 g, fibre 1.0 g, Ca 29 mg, P 19 mg, Fe 0.4 mg, β-carotene 450 μg, thiamin 0.16 mg, riboflavin trace, niacin 0.1 mg, folate 10 μg, ascorbic acid 14 mg (Holland, B., Unwin, I.D. & Buss, D.H., 1991).

The composition of pumpkin leaves per 100 g is: water 89.2 g, energy 113 kJ (27 kcal), protein 4.0 g, fat 0.2 g, carbohydrate 4.4 g, fibre 2.4 g, Ca 477 mg, P 136 mg, Fe 0.8 mg, β-carotene 3600 μg, thiamin 0.06 mg, riboflavin 0.32 mg, ascorbic acid 80 mg.

The composition of pumpkin seeds (without shell) per 100 g is: water 5.5 g, energy 2331 kJ (555 kcal), protein 23.4 g, fat 46.2 g, carbohydrate 21.5 g, fibre 2.2 g, Ca 57 mg, P 900 mg, Fe 2.8 mg, thiamin 0.15 mg, niacin 1.4 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968).

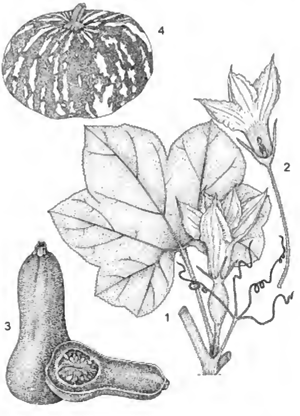
All cucurbits contain triterpene glycosides called cucurbitacins. These compounds are present in all plant parts in different concentrations. If concentrated in the edible parts, they cause a bitter taste. The medicinal properties of the pumpkin may be attributed to these cucurbitacins, which can also be poisonous. In the United States cucurbitacin B is used as a feeding stimulant in the control of the western corn rootworm *Diabrotica virgifera*.

Clinical trials in Thailand confirmed that seed extracts can kill tapeworms and schistosomes (blood flukes). Tests in Japan with mice suggested that *Cucurbita moschata* extracts may

be useful for the suppression of antibodies in certain allergic disorders.

Adulterations and substitutes For the use of the fruits, leaves and seeds *Cucurbita moschata* can be substituted by those of *Cucurbita maxima* Duchesne, although the leaves of *Cucurbita maxima* are regarded as a bit coarse, this characteristic disappearing with cooking. The seeds of egusi (*Cucumeropsis mannii* Naudin and *Citrullus lanatus* (Thunb.) Matsum. & Nakai) are the most common cucurbit seed products.

Description Annual, scandent herb, climbing by lateral, 3–4-branched tendrils, strongly branched; stems obtusely angular, long running, initially pubescent, often rooting at nodes. Leaves alternate, simple, without stipules; petiole 9–24 cm long, grooved; blade broadly ovate in outline, shallowly palmately 5–7-lobed, (10–)20–35 cm in diameter, deeply cordate at base, margins toothed, softly hairy, sometimes with white markings disappearing at senescence, 3-veined from the base. Flowers solitary, unisexual, regular, 5-merous, large, 10–20 cm in diameter, lemon yellow to deep orange; sepals free, subulate to linear, 1–3 cm long; corolla campanulate, with widely spreading lobes; male flowers long-pedicelled (up to 16 cm), with 3 stamens, filaments free, anthers usually connivent into a long twisted body; female flowers shortly pedicelled (up to 3.5 cm), with inferior, ellipsoid, 1-celled ovary, style thick, stigmas 3, 2-lobed. Fruit a large, globose to ovoid or cylindrical berry, weighing up to 10 kg, with a wide range of colours, often covered with green spots and grey stripes, with small, raised, wartlike spots; flesh yellow to orange, many-seeded; fruit stalk enlarged at apex. Seeds obovoid, flattened, 1–2 cm × 0.5–1 cm, usually white or tawny, sometimes dark-coloured, surface smooth to somewhat rough, margin prominent. Seedling with epigeal germination; hypocotyl 2–3 cm long; cotyledons elliptical, 2–4 cm long, cuneate at base, obtuse at apex, entire.



Cucurbita moschata – 1, stem fragment with female flower; 2, male flower in longitudinal section; 3, fruit ('Butternut'); 4, young fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information It is often not easy to distinguish *Cucurbita moschata* plants or fruits from the related *Cucurbita pepo* L. and *Cucurbita maxima*. The plant habit is similar and the fruit shape and size are variable. Distinction is easiest by observing differences of the fruit stalk, stems and leaves. *Cucurbita moschata* has a hard, smoothly angled fruit stalk widened at apex, hard, smoothly grooved stems and soft, moderately lobed leaves. *Cucurbita maxima* has a soft, rounded fruit stalk not enlarged at apex, soft, rounded stems and soft, usually unlobed leaves. *Cucurbita pepo* has an angular fruit stalk sometimes slightly widened at apex, hard, angular, grooved, prickly stems and palmately lobed, often deeply cut and prickly leaves.

Many landraces of *Cucurbita moschata* occur, the fruit form varying from cylindrical to globose or ovoid. For improved cultivars of *Cucurbita moschata* in the Americas three cultivar groups are distinguished, based on the fruit form:
- Cheese Group: fruit oblate (flattened), more or less ribbed, with buff-coloured rind and deep orange flesh;
- Crookneck Group: fruit elongated with curved or straight neck;
- Bell Group: fruit bell-shaped or cylindrical, e.g. cultivar 'Butternut'.

Although rural farmers in Africa grow their own landraces, improved cultivars are slowly coming on to the African market.

Growth and development Seed germinates in 5–7 days from sowing. The plants form an extensive fibrous root system. Growth is

indeterminate; under suitable conditions, stems will continue to grow as long as they can root at the nodes and may reach a length of more than 20 m. Flowering starts 35–60 days after emergence and is more or less continuous. The ratio of male to female flowers is around 20:1. This ratio is influenced by the growing conditions. Long days and high temperatures favour the male sex expression. Pollen is sticky and production is abundant. Anthesis and pollination take place early in the morning. Insects, mainly bees, effect pollination; flowers are predominantly cross-pollinated. One or two fruits per stem develop. The fruit matures 30–40 days after pollination. The harvest period extends from 2 to 6 months after sowing.

Ecology Musk pumpkin is grown in the tropics up to about 1800 m altitude. For optimal growth it needs high day temperatures, above 20°C and night temperatures above 14°C. It is almost photoperiod insensitive or shows a slight short-day reaction, and may be grown year round, although it is usually grown during the rainy season without any irrigation. It tolerates some shading. Musk pumpkin is not very demanding with respect to soil conditions and can be cultivated on almost any reasonably fertile, well-drained soil with a neutral or slightly acid reaction (pH 5.5–6.8). It is fairly drought tolerant, but sensitive to frost and waterlogging. Excessive humidity during the rainy season stimulates the development of fungal and bacterial diseases causing leaf decay, wilting and fruit rot.

Propagation and planting Musk pumpkin is grown from seed (1000-seed weight about 200 g). As it roots at the nodes it might be grown from cuttings, but this method is not practised except for research purposes. Farmers sow in small hills (planting holes) on flat land or raised beds, 2–4 seeds per hill. It can be sown in containers and the seedlings transplanted into the field when they are about 10 cm tall, but direct seeding is generally practised. A common planting distance is 2 m × 2 m, giving a plant population of 2500 hills/ha. The seed requirement is 2–3 kg/ha, but many farmers use much more seed, up to 7 kg/ha. Because of the branching and creeping plant habit, the optimal planting density is flexible; the number of hills (with 1–4 plants/hill) varies from 600 to 4000 per ha. 'Butternut' types are often grown at a spacing of 120 cm × 50–70 cm. With a dense planting, the soil will be covered and weed will be suppressed sooner.

Management The traditional cropping system of musk pumpkin for leaves and/or fruit production is intercropping in maize or sorghum fields. It is also planted on termite hills, fertile patches of abandoned homesteads and kraals. Sole cropping is the appropriate system for commercial pumpkin production of improved cultivars, but in African countries this is still in its infancy. Pumpkins grow well on organic matter and are often encountered on refuse heaps. The crop responds well to farm manure and to side dressings of liquid manure. Depending on soil fertility, the following applications are recommended: 50–100 kg/ha N, 20–40 kg/ha P and 40–80 kg/ha K during the vegetative phase. A part of the minerals can be applied as a top dressing of NPK 10–10–10, e.g. 50 kg/ha at the first fruit setting. Irrigation should be applied under dry conditions, e.g. 50 mm weekly. Sometimes the tips are removed to check growth and promote branching.

In intensive cultivation in South East Asia, recommended cultural practices include the use of plastic mulch, removal of growing tips to improve branching and development, bagging fruits in paper to protect against fruit fly, and sometimes even manual pollination to increase fruit set.

Diseases and pests Many diseases and pests attack *Cucurbita moschata*, but only a few are really problematic. Alternaria leafspot or leaf blight caused by *Alternaria cucumerina* is a fungus disease, which may defoliate and kill affected plants within weeks. This fungus also causes fruit rot. In affected plants, small round whitish necrotic spots, later with concentric circles, appear on the oldest leaves; these turn grey and yellow and dry out. Use of healthy seed, removal of plant debris and crop rotation are means to control the disease. Gummy stem blight (gummy canker) on stems and black rot on fruits caused by *Didymella bryoniae* (anamorph: *Phoma cucurbitacearum*) is a serious cause of crop losses everywhere. First the nodes with nearly ripe fruits are attacked, they become oily-green and sap exudes forming drops of gum. The stem beyond the affected area wilts. The fungus also causes seedling death and fruit stalk canker. Control is possible by using healthy seed, protective fungicides (e.g. mancozeb) and crop rotation. No cultivar resistance has been reported. Downy mildew caused by *Pseudoperonospora cubensis* may become a devastating disease under high air humidity. It starts on older leaves with pale green to yellowish angular spots, bounded by leaf veins. The lower surface

is covered with a faint purplish fungus-fruiting layer and the entire leaf rolls upwards and dies. Downy mildew can be controlled by wide spacing, good drainage and aeration, and crop rotation. Resistance has been found in India. Fusarium wilt (*Fusarium oxysporum*) causes yellowing of the leaves followed by wilting and stunting of stems or the whole plant. Control is possible by using healthy seed, removal of debris, crop rotation, and avoiding excessive nitrogen fertilization. Resistance has been observed. Anthracnose caused by *Colletotrichum lagenarium* is a destructive disease worldwide. It causes defoliation and lesions on the fruits. Day temperatures of 26–30°C combined with night temperatures of 18–20°C and intermittent rain are most congenial to disease development. Seed treatment and applying systemic fungicides may provide effective control. Powdery mildew (*Erysiphe cichoracearum*) may occur under low humidity. The upper side of the leaves is covered with the white powdery fungus growth, and the leaves become yellowish and dry out. Control is possible with fungicides and resistance has been found. Other diseases are scab (*Cladosporium cucumerinum*) causing small spots on all plant parts, and Choanephora wet rot (*Choanephora cucurbitarum*) causing fruit rot. Important virus diseases are cucumber mosaic (CMV), papaya ring spot (PRSV-W), squash leaf curl (SLCV), watermelon mosaic (WMV-2) and zucchini yellow mosaic (ZYMV). These viruses often occur in combination. They are spread by mechanical infection and insects, and probably to some extent by seed transmission. The risk of contamination is reduced by keeping the population of virus-transmitting insects (aphids, whitefly and thrips) low. Partial resistance is present in some cultivars. The USA butternut cultivar 'Batangas Native' is resistant to CMV. The Philippine cultivars 'Arjuna F_1' and 'Oringo F_1' (East West Seed Company) are highly tolerant to viruses.

Insect pests are seldom serious on musk pumpkin. Whiteflies (e.g. *Bemisia* spp.) and spider mites (*Tetranychus* spp.) may cause damage. Whiteflies cause silvering of the leaves. Leaf-feeding *Epilachna* beetles may be harmful on young plants. The gourd ladybird *Henosepilachna elaterii* is reported as a major pest on pumpkins in Sudan.

Harvesting The elongating stems supply a good quantity of leaves, which are removed in succession. When grown as leaf vegetable, usually the third and fourth leaves are harvested, while the tip and second leaves are left to grow. Young leaves and shoots are picked when needed. The leaf harvest may start 6 weeks after sowing and may be continued for at least 2 months with one harvest per week. Care should be taken that one does not tread on the stems. Male flowers are sometimes harvested for consumption.

Pumpkin fruits are picked when nearly or fully mature 4–6 weeks after flowering, and are harvested in several rounds until the crop ends, 90–180 days after planting. Some farmers will leave the fruits lying in the fields for weeks. Seeds are extracted as the fruits are consumed. Some seeds are stored for future planting and others are used as food.

Yield The number of mature fruits harvested per plant is low, and the weight of individual fruits varies widely from 1–10 kg, mainly depending on cultivar. Under low input conditions, the yield is around 5 t/ha; with good care, a yield of 15 t/ha is reasonable. With improved cultivars a yield of 30 t/ha is attainable. An average yield of leaves is 2 t/ha per picking, or about 20 t/ha during a harvest period of two months. Seed yield is variable, possibly 300–500 kg/ha. If grown for seed production, isolation between fields of musk pumpkin and of other *Cucurbita* species is recommended, not only to maintain seed purity, but also to obtain maximum yields, as pollen of other species may cause reduced fruit set and parthenocarpic fruits. In proper seed extraction procedures, mature fruits are split and the seed is collected, fermented, washed, cleaned and dried.

Handling after harvest As the leaves of musk pumpkin are highly perishable, many people prefer to grow the crop in their own garden, rather than buying it in the market. When grown for sale at local markets, leaves are tied in bundles and these are kept moist, e.g. under a jute bag. Leaves are often stored in dried form. For that purpose, they are cut into small pieces and spread in the open to dry during 1–2 days depending on weather conditions. The dried leaves are stored in containers and are used during the dry season. Fruits can be stored a long time on slatted shelves with good ventilation, the butternut type for at least one month, big pumpkins for several months; storage at 10–16°C and 70% humidity is most appropriate. In cool store, chilling injury occurs at temperatures below 10°C. Pumpkin flesh can also be dried in strips for later use in soups and stews.

Genetic resources *Cucurbita* species are

well represented in the *Cucurbitaceae* germplasm collections of many institutions all over the world. The National Seed Storage Laboratory (NSSL), Fort Collins, Colorado, United States, and the Vavilov Institute of Plant Industry (VIR), St. Petersburg, Russia maintain important base collections. Large collection of *Cucurbita moschata* are present in the genebank of NBPGR in New Delhi, India, at NPGRL, Los Baños, the Philippines, at NIAS, Ibaraki, Japan, at INIA, Celaya, Mexico, and at CATIE, Turrialba, Costa Rica. Little attention has been given to the African landraces. Nigerian local cultivars, known as 'Nigeria Local' are used by western seed companies as genitors for virus resistance (CMV, PRSV, WMV and ZYMV). In Malawi, an evaluation of 121 local pumpkin landraces showed great variation in fruit sizes, shape and colour; a combination of mean fruit weight and number of fruits per plant are valuable characters for yield improvement. In Zimbabwe, large numbers of local accessions discernible by fruit colour, size, rind hardness, flavour, texture and keeping quality have been selected. Systematic collection is urgently needed. *Cucurbita moschata* is a mandate species of the Southern African Developing Countries Plant Genetic Resources Centre (SPGRC) at Lusaka, Zambia.

Breeding *Cucurbita moschata* is naturally cross-pollinated but self-compatible, inbreeding causing little loss of vigour. A considerable degree of heterosis of inbred lines has been observed. Hand-pollination of the large flowers is an easy operation. Seed companies are less interested in open-pollinated cultivars and commercialize many F_1-hybrids. Seed company Technisem developed the F_1 cultivar 'Martinica' especially for tropical lowland. Breeding work in the tropics is rare and very little breeding work has been reported from tropical Africa. The South African F_1 cultivar 'Barbara' is a butternut type introduced in southern Africa (Zimbabwe, Zambia). It combines earliness, high-yielding capacity, disease resistance and a high carotene content. About 30 genes known to control qualitative characters have been described in the cultivated *Cucurbita* species. Desirable traits are available in related wild species, such as powdery mildew resistance in *Cucurbita lundelliana* L.H.Bailey. A study of molecular markers in 31 landraces from Zambia and Malawi revealed 4 clusters of genotypes.

The interspecific cross of *Cucurbita moschata* with *Cucurbita maxima* and *Cucurbita mixta* Pangalo results in a viable F_1 but sterile progeny; with *Cucurbita pepo* in sparingly fertile F_1 plants, the F_2 plants being sterile; with *Cucurbita ficifolia* Bouché in fruits without seed. A Japanese company developed a commercial interspecific F_1 hybrid with *Cucurbita maxima* and *Cucurbita moschata* lines as parents. No spontaneous hybridization between the five cultivated *Cucurbita* species (*Cucurbita ficifolia*, *Cucurbita maxima*, *Cucurbita mixta*, *Cucurbita moschata* and *Cucurbita pepo*) has been reported. Results of interspecific hybridization suggest that the sterility barriers are genic rather than the result of a lack of chromosomal homology, which means that heterozygosity improves the chances of obtaining interspecific hybrids.

Prospects *Cucurbita moschata* is a highly appreciated, multipurpose vegetable, easy to cultivate, potentially high yielding and with a high nutritional value. It has been neglected by formal research. In Africa cultural practices are still extensive and yield levels are low; (almost) no breeding for yield, disease resistance and quality has been performed. With the introduction of improved cultivars, ancient landraces are in danger of disappearing. Germplasm collection of African landraces deserves priority. In addition to development of improved cultivars for the fruits, attention should be paid to the potential of the leaves and seed, and to seed as a source of vegetable fat and protein. Hybrid cultivars with virus resistance genes have a large potential.

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CUCURBITA PEPO L.

Protologue Sp. pl. 2: 1010 (1753).

Family Cucurbitaceae

Chromosome number $2n = 40$

Vernacular names Courgette, zucchini, summer squash, vegetable marrow, pumpkin (En). Courgette, courge, citrouille (Fr). Abobrinha, aboborinha, abóbora (Po). Mboga (Sw).

Origin and geographic distribution The centre of origin of *Cucurbita pepo* is Mexico, where it was domesticated at least 5000 years ago. It is sometimes believed that it was domesticated on separate occasions in Mexico and the United States as data from archaeological research and molecular studies suggest that two lineages of domesticated taxa exist in *Cucurbita pepo*. It was introduced in Europe with other *Cucurbita* species during the 16th century. *Cucurbita pepo* is less heat resistant than *Cucurbita moschata* Duchesne, and for that reason less appropriate for tropical Africa, yet it is grown on a limited scale in all countries. It is traditionally more important in francophone than in anglophone countries and is mainly grown in the vicinity of big cities, especially for European and Lebanese customers.

Uses The immature fruits, called courgette, zucchini or summer squash, are the main product of *Cucurbita pepo*. They are eaten as a vegetable, either boiled or fried or stuffed. Mature fruits, called winter squash or pumpkin, are used peeled and cooked like the fruits of *Cucurbita maxima* Duchesne, or following the Anglo-Saxon tradition, prepared as pumpkin pie. In West Africa the fruits are used in soups and with couscous. Gem squashes, small globular fruits popular in southern Africa, are cooked whole or cut in half and their flesh is scooped out and eaten. The young leaves and shoots are used as a potherb e.g. in south-western Nigeria, but in general the leaves of *Cucurbita moschata* are preferred, being less coarse. Male flowers of courgette are sometimes used to make fritters. 'Vegetable spaghetti' cultivars are a speciality; when cooked the flesh of mature fruits resolves into thin strands which look like spaghetti. *Cucurbita pepo* seeds are edible in the same way as those of other cucurbits, either raw or roasted. Pumpkin seed powder is used in China and the United States as an ingredient of salad dressings and in baked products. The seed oil is used as salad oil in Europe, and in India for cooking and lighting. The seed is becoming popular for its medicinal properties including the prevention of kidney stones. In Africa the pulp is used as a poultice to treat burns and inflammations and as a cooling compress to treat headache and neuralgia; it has also been applied to tumours and corns. Seeds are eaten as an anthelmintic. In Mauritius an infusion of the seeds is used internally to treat hypertension and prostate complaints, and externally to treat erysipelas.

The fruit pulp has been used to dehair and soften hides in tanning. In Western countries special cultivars are grown for the nicely shaped and coloured fruits ('coloquintes'). The fruits of these ornamental cultivars have a hard rind and are not edible. Pumpkins are sometimes grown for animal feed.

Cucurbita pepo – planted

Production and international trade International statistics on production and trade rarely distinguish between *Cucurbita pepo* and other *Cucurbita* species; this especially affects information on tropical Africa, where *Cucurbita pepo* is less important than *Cucurbita moschata* or *Cucurbita maxima*. FAO statistics for 2002 estimate world production of pumpkins, squashes and gourds (*Lagenaria*) at 17.7 million t from 1.4 million ha. China is by far the most important producer (4 million t, mainly *Benincasa*), followed by India (3.5 million t), Ukraine (0.9 million t) and the United States (750,000 t). For tropical Africa substantial production is reported in Cameroon (122,000 t),

Rwanda (210,000 t) and Sudan (68,000 t). During winter there is some export of courgette from East Africa to western Europe and occasionally to the Arab states. Countries in northern Africa, e.g. Morocco, also export courgette to Europe.

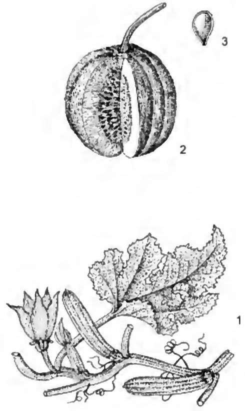
Properties The nutritional composition of *Cucurbita pepo* fruits varies somewhat with type and degree of maturity. Zucchini is highest in water content and lowest in calories, winter squash lowest in water and highest in energy; summer squash, pattypan and other types eaten unripe are similar to zucchini although somewhat lower in water and higher in energy and nutrients; pumpkin is similar to winter squash. Types with yellow to pink fruit flesh are rich in vitamin A.

The composition of zucchini per 100 g edible portion (raw, 95% as purchased) is: water 95.3 g, energy 59 kJ (14 kcal), protein 1.2 g, fat 0.14 g, carbohydrate 2.9 g, dietary fibre 1.2 g, Ca 15 mg, Mg 22 mg, P 32 mg, Fe 0.4 mg, Zn 0.2 mg, vitamin A 340 IU, thiamin 0.07 mg, riboflavin 0.03 mg, niacin 0.4 mg, folate 22 μg, ascorbic acid 9.0 mg. The composition of winter squash per 100 g edible portion (raw, 71% as purchased) is: water 88.7 g, energy 155 kJ (37 kcal), protein 1.5 g, fat 0.2 g, carbohydrate 8.8 g, dietary fibre 1.5 g, Ca 31 mg, Mg 21 mg, P 32 mg, Fe 0.6 mg, Zn 0.13 mg, vitamin A 4060 IU, thiamin 0.10 mg, riboflavin 0.03, niacin 0.8 mg, folate 22 μg, ascorbic acid 12.3 mg. The composition of pumpkin leaves (*Cucurbita* sp.) per 100 g edible portion (raw, 61% as purchased) is: water 92.9 g, energy 80 kJ (19 kcal), protein 3.2 g, fat 0.4 g, carbohydrate 2.3 g, Ca 39 mg, Mg 38 mg, P 104 mg, Fe 2.2 mg, vitamin A 1942 IU, thiamin 0.09 mg, riboflavin 0.13 mg, niacin 0.9 mg, ascorbic acid 11 mg. The composition of pumpkin and squash seed kernels per 100 g edible portion (raw, 74% as purchased) is: water 6.9 g, energy 2265 kJ (541 kcal), protein 24.5 g, fat 45.8 g, carbohydrate 17.8 g, dietary fibre 3.9 g, Ca 43 mg, Mg 535 mg, P 1174 mg, Fe 14.9 mg, Zn 7.5 mg, vitamin A 380 IU, thiamin 0.21 mg, riboflavin 0.32 mg, niacin 1.7 mg, folate 58 μg, ascorbic acid 1.9 mg (USDA, 2002).

Fruits of *Cucurbita pepo*, especially ornamental forms, may contain bitter compounds; cucurbitacins B, D, E, G and I and the glycoside of cucurbitacin E have been recorded. Seeds (as reported from Eritrea) are rich in oil (about 35%) and contain protein 38%, carbohydrate 37% and α-tocopherols. The oil contains linoleic acid 47%, oleic acid 29%, palmitic acid 13.5% and stearic acid 8%. Seed extracts showed insecticidal activities against mosquitoes and flies, and reduction of arterial tension in chickens. The ribosome-inactivating protein pepocin has been isolated from *Cucurbita pepo* fruits.

Adulterations and substitutes Cultivars of *Cucurbita ficifolia* Bouché, *Cucurbita maxima* and *Cucurbita moschata* are used for the same purposes as *Cucurbita pepo*.

Description Annual, scandent herb, climbing by lateral, 3–4-branched tendrils, strongly branched, or with bushy habit and then often without tendrils; stems angular and often grooved, prickly hairy, often rooting at nodes. Leaves alternate, simple, without stipules; petiole 9–24 cm long, grooved; blade broadly ovate to triangular in outline, distinctly palmately 5–7-lobed, (10–)20–35 cm in diameter, deeply cordate at base, margins toothed, bristly hairy, often with white markings, 3–5-veined from the base. Flowers solitary, unisexual, regular, 5-merous, large, c. 10 cm in diameter, lemon yellow to golden yellow; sepals free, subulate to linear, 1–3 cm long; corolla campanulate, with erect to spreading lobes; male flowers long-pedicelled, with 3 stamens, fila-



Cucurbita pepo – *1, flowering and fruiting branch (courgette); 2, fruit (gem squash); 3, seed.*
Redrawn and adapted by Iskak Syamsudin

ments free, anthers usually connivent into along twisted body; female flowers shortly pedicelled, with inferior, rounded to ellipsoid, 1-celled ovary, style thick, stigmas 3, 2-lobed. Fruit a large, globose to ovoid, obovoid, cushion-shaped or cylindrical berry, weighing up to 50 kg when mature, with a wide range of colours, with small, raised, wartlike spots or smooth, sometimes deeply grooved; flesh whitish to yellow or orange, many-seeded; fruit stalk pentagonal in section, not enlarged at apex. Seeds obovoid, flattened, 1–1.5 cm × 0.5–1 cm, usually white or tawny, surface smooth to somewhat rough, margin prominent. Seedling with epigeal germination.

Other botanical information Principal features distinguishing *Cucurbita pepo* from other cultivated *Cucurbita* species are more deeply lobed leaves with silvery markings, prickly hairy stems and leaves and fruit stalk hard and pentagonal in cross-section.

Supposedly wild populations of *Cucurbita pepo* are known from northern Mexico (subsp. *fraterna* (L.H.Bailey) D.S.Decker) and eastern United States (subsp. *ovifera* (L.) D.S.Decker var. *ozarkana* D.S.Decker and var. *texana* (Scheele) Filov). These are all considered candidates for the progenitor of cultivated *Cucurbita pepo*, which has been divided into 2 taxa, subsp. *pepo* and subsp. *ovifera* var. *ovifera* (L.) Harz.

Several cultivar classifications have been proposed, but none has been widely accepted. Mediterranean type cultivars called courgette or zucchini, grown for the immature cylindrical fruits, are most important for tropical Africa. The American or English types, known as vegetable marrow, summer squash, cocozelle, crookneck and straightneck are also grown for their young fruits, whereas pumpkin or winter squash, acorn types and also local African cultivars (old introductions) are grown for the mature fruits.

Modern courgette cultivars are mostly characterized by a bushy growth type. Fruits of these cultivars are mostly elongate, but some are spherical (e.g. 'Courgette Ronde de Nice') or flattened and star-like (scalloped summer squash, pattypan or pâtisson). Coussa types, popular in the Middle East, are eaten when nearly mature; they are often stuffed with meat, spices and rice. Vegetable marrow and vegetable spaghetti cultivars are vigorous trailing plants. Gem squash is popular in southern Africa (Malawi, Zambia, Zimbabwe, South Africa). Some cultivars produce naked kernels, an interesting character if edible seed production is wanted.

Growth and development Seeds germinate 5–7 days after sowing, or earlier if the seed-coat is carefully split or peeled. Plants develop an extensive fibrous root system and their growth is indeterminate. Under favourable conditions stems may grow up to 15 m long and root at the nodes. Many modern cultivars of courgette have a bushy habit characterized by short internodes and sparse or no branching. Flowering starts 30–40 days after emergence of the seedling, and is more or less continuous. Pollination is by insects, mainly bees and wasps. The first immature fruits can be harvested 50–60 days after germination. Mature fruits can be harvested after 90–100 days. Under cool temperatures (nights 10°C, days 20°C) parthenocarpic fruit set may take place.

Ecology *Cucurbita pepo* tolerates monthly average day temperatures of 18–28°C, but growth is best when day temperatures are between 24°C and 29°C and night temperatures between 16°C and 24°C, as found at high altitudes in East Africa or at higher latitudes. Production is mostly restricted to the beginning of the dry season, when temperatures are relatively low and the pressure of aphids less intense.

Cucurbita pepo behaves as day-neutral. It is drought tolerant, but requires about 2.5 cm water per week for good production. It prefers fertile, well-drained soils of pH 5.6–8.0. Aluminium and manganese toxicity in acid soils must be corrected by liming. In bush cultivars heavy rains (more than 40 mm in one day) quickly induce symptoms of waterlogging and splitting of the stem, which finally breaks; since there are no axillary buds, these plants are lost. For this reason, and also because of its higher susceptibility to diseases and slower growth rate at high temperatures, *Cucurbita pepo* is less adapted to tropical lowlands than *Cucurbita moschata*, especially during the rainy season.

Propagation and planting All *Cucurbita pepo* types are grown from seed. Trailing plants may be propagated by cuttings, but this is not done in practice. Several seeds of courgette or pumpkin are sown directly in small hills; for bush cultivars only one plant per hill is left. Seeds are placed about 2.5 cm deep. For bush cultivars 40,000 plants/ha are planted in double rows, on beds 1.2 m wide, or on equidistant hills 50 cm apart. Trailing cultivars should be sown at wide spacing with 5000–

10,000 plants/ha because they cover the soil surface for several metres around. Growing seedlings in a nursery and transplanting is recommended when costly F_1 seeds are used.

Management Growth and productivity of *Cucurbita pepo* plants respond very well to large applications of organic matter (farm manure or compost), which need not be fully decomposed (NH_3 emissions are well tolerated). The organic matter should preferably be incorporated in the planting hole or furrow, in amounts of 50–70 t/ha. The crop also responds well to a complementary application of mineral fertilizer, e.g. 150 kg N, 150 kg P and 300 kg K, one half before planting, the other half 30 days later. Placement of bee hives in the field during flowering often improves pollination and yield.

Diseases and pests *Cucurbita pepo* is more susceptible to diseases present in the humid lowland tropics than *Cucurbita moschata*. The principal leaf disease is powdery mildew, caused by *Erysiphe cichoracearum* (or especially in dryer conditions *Sphaerotheca fuliginea*). *Alternaria* or *Ulocladium* spp. can sometimes cause necrotic leaf spots. Downy mildew (*Pseudoperonospora cubensis*), very destructive on cucumber and muskmelon, induces only localized small yellow lesions, except in Japan, where a virulent strain was described on *Cucurbita* spp. *Didymella bryoniae* causes leaf spot mostly on senescent petioles only. Temperatures in the lowland are higher than optimal for the development of anthracnose (*Colletotrichum lagenarium*) and scab (*Cladosporium cucumerinum*), but these fungi of leaves and fruits may occur at higher elevations. A number of other fungi can attack the young fruits. Wet rot (*Choanephora cucurbitarum*) first invades the corolla, then the blossom-end of the fruit. *Pythium aphanidermatum* and *Phytophthora capsici* invade the fruits directly from the soil, the zoospores or conidia being splashed on the fruits by heavy rain. Direct contact with the soil can also cause *Rhizoctonia solani* or *Sclerotium rolfsii* fruit rots. Plastic mulch may give good control of these soil-linked diseases, provided water can freely drain off from the mulch. Roots and stem bases of *Cucurbita pepo* may be invaded by *Pythium aphanidermatum*, *Phytophthora capsici*, *Rhizoctonia solani* and occasionally by the seedborne *Fusarium solani* f.sp. *cucurbitae*. The most important root diseases are caused by root-knot nematodes (*Meloidogyne* spp.), against which manuring with organic matter under the plants is a good control measure.

Several viruses can infect *Cucurbita pepo*. The most important in the lowland tropics is the papaya ringspot potyvirus-W (PRSV-W), also called watermelon mosaic virus-1 (WMV1). Cucurbit beetles (*Epilachna*, *Diabrotica*, *Acalymma* spp.) are vectors of the seedborne squash mosaic virus (SqMV). The cucumber mosaic virus (CMV), watermelon mosaic potyvirus-2 (WMV2) and zucchini yellow mosaic potyvirus (ZYMV) are noxious viruses in subtropical countries, but are rarely observed in the tropics. Several whitefly-transmitted viruses attack *Cucurbita pepo* in temperate and subtropical regions, but have not been observed in tropical Africa.

Direct insect damage may be caused by *Aphis gossypii*, *Epilachna* spp. and other beetles, *Bemisia argentifolia* (synonym: *Bemisia tabaci* strain B), pickle worm (*Diaphania nitidalis*) and melon worm (*Diaphania hyalinata*, synonym: *Margaronia hyalinata*). Fruit flies (*Dacus cucurbitae*) cause serious losses in West Africa. Spider mites (*Tetranychus* spp.) can invade the leaves when day temperatures are higher than 30°C.

Harvesting Courgette fruits are best harvested at a commercial size of 20–25 cm, long before the seeds differentiate from the flesh. At that stage the fruits have reached about one quarter of their final size. This may start 55–60 days after sowing. Gem squash is ready for harvesting once the outer skin starts hardening but before the seeds have matured. At that stage they are about 6 cm in diameter. The plot should be visited every day since fruits enlarge very quickly. The harvest period may last 30–40 days. Pumpkin cultivars grown for mature fruits are harvested once over at the early maturity stage.

Yield Bush cultivars produce 5–8 fruits per plant, trailing cultivars many more. F_1 hybrid courgette cultivars grown under optimal cultural practices, such as adequate organic and mineral fertilizing, regular irrigation, adequate control of diseases and absence of heavy rains, may yield up to 80 t/ha. In tropical Africa, an average yield level is 20 t/ha.

Handling after harvest Immature fruits are very susceptible to damage and must be carefully handled and put into baskets or crates coated with paper or plastic. They cannot be kept longer than 5–6 days at temperatures of 25–35°C. Optimum storage temperature is 10°C, with a storage life of 20–25 days. Larger fruits for family use (40–50 cm long for courgette or vegetable marrow) can be kept one

month or more at 25°C. Mature fruits can be stored for several months. The pulp may be cut into chips or strips and dried for later use in soups.

Genetic resources Important collections of *Cucurbita pepo* are preserved in a number of institutes in the world, e.g. Institute of Crop Germplasm Resources (CAAS), Beijing, China (390 accessions), Genebank Department, Vegetable Section Olomouc, RICP Prague, Czech Republic (380), Universidad de San Carlos (FAUSAC), Guatemala City, Guatemala (475), N.I. Vavilov All-Russian Scientific Research Institute of Plant Industry, St. Petersburg, Russian Federation (325), Banco de Germoplasma de Horticolas, Zaragoza, Spain (350) and North Central Regional Plant Introduction Station, USDA-ARS, Ames, IA, United States (860).

Breeding *Cucurbita pepo* is naturally cross-pollinated but self-compatible. Inbreeding does not induce significant loss of vigour. Traditional cultivars offered by seed companies are true inbred lines; they offer an easy start for development of F_1 hybrids, which yield 50–100% more than open-pollinated cultivars. F_1 seed is obtained either by hand pollination, or by planting both parents in the field side by side, the female one developed by 2-chloroethyl-phosphonic acid sprays. Commercial hybrids belong to the bush type. F_1 hybrids between bush and trailing cultivars were tried in the West Indies. They give robust and highly productive plants with stems 1–1.5 m long, less susceptible to breakage after heavy rains.
Interspecific hybridization is possible with *Cucurbita maxima* and *Cucurbita moschata*, but the progeny is not fertile. Genes can be transferred to vegetable cultivars from any cultivated type of *Cucurbita pepo*, including small-fruited cultivars grown as ornamentals, as well as from closely related wild taxa (e.g. var. *texana*). Interesting characters such as powdery mildew and virus resistances have been transferred to *Cucurbita pepo* from wild *Cucurbita* species. Commercial hybrids with powdery mil-dew resistance are appearing in seed catalogues.

Prospects In tropical Africa old trailing pumpkin cultivars of *Cucurbita pepo* will be replaced by *Cucurbita moschata*, more resistant to tropical conditions and diseases. Courgette is becoming increasingly popular. The availability of cultivars, possibly F_1 hybrids, accumulating resistance to powdery mildew and viruses, lower susceptibility to stem breaking and resistance to high temperatures would make production easier for the local market. Prospects for export production in tropical African countries during the winter to Europe are not favourable as they would have to compete with countries in northern Africa (e.g. Morocco) and Spain (Andalusia).

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Other references Andres, T.C. & Tukey, H.B. Jr., 1995; Gurib-Fakim, A., Guého, J. & Bissoondoyal, M.D., 1996; Holland, B., Unwin, I.D. & Buss, D.H., 1991; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Mossler, M.A. & Nesheim, O.N., 2001; von Tschermak-Seysseneg, E., 1934; Widjaja, E.A. & Sukprakarn, S., 1993; Younis, Y.M., Ghirmay, S. & al Shihry, S.S., 2000.

Sources of illustration Hegi, G., 1979a; Vaughan, J.G. & Geissler, C.A., 1997.

Authors C.-M. Messiaen & J.A. Fagbayide

CYCLANTHERA PEDATA (L.) Schrad.

Protologue Ind. sem. hort. acad. Goetting. (1831); Linnaea 8, Litt. Berichte: 23 (1833).

Family Cucurbitaceae

Chromosome number $2n = 16, 32$

Vernacular names Slipper gourd, lady's slipper, stuffing cucumber, achocha (En). Achocha (Fr). Tamiá de comer, tamiá de cipô (Po).

Origin and geographic distribution *Cyclanthera pedata* is a native of Andean South America, but now only known in cultivation or as an escape. It is cultivated from Mexico to Peru and Ecuador and also in the Old World tropics. In Africa cultivation is restricted to highlands of East Africa.

Uses Young fruits are eaten raw or pickled. Older fruits are eaten after removal of the seeds and boiling. The taste is similar to that of cucumber. Young shoots and leaves are eaten as greens. *Cyclanthera pedata* has the reputation of being anti-inflammatory, hypocholesterolaemic and hypoglycaemic. An extract of the fruit is marketed under the name Cycladol.

Properties The fruit contains per 100 g: water 94 g, protein 0.6 g, fat 0.1 g, carbohydrate 4 g, fibre 0.7 g, Ca 14 mg, P 14 mg, Fe 0.8 mg, thiamin 0.04 mg, riboflavin 0.04 mg, niacin 0.3 mg, ascorbic acid 14 mg (Rubatzky & Ya-

maguchi, 1997).
Investigations into the chemical constituents of *Cyclanthera pedata* seeds and fruits have revealed the presence of 6 flavon glycosides, 9 triterpenoid saponins and 6 cucurbitacin glycosides.

Botany Annual, monoecious vigorous vine; stem up to 5 m long, glabrous; tendrils bifid. Leaves alternate, palmately 3–5-foliolate or simple but very deeply lobed; stipules absent; petiole 1–8 cm long; leaflets or lobes elliptical, sinuate-serrate. Flowers unisexual, regular, 5-merous; male flowers in axillary, 10–20 cm long panicles; female flowers solitary, with inferior, 1-celled ovary. Fruit an indehiscent, obliquely ovoid berry up to 16 cm long, tapering, flattened, white-green, sometimes with soft spines, many-seeded. Seeds c. 1.5 cm in diameter, black.
Cyclanthera is placed in *Cyclanthereae*, an entirely New World tribe. *Cyclanthera brachystachya* (Ser.) Cogn. (synonym: *Cyclanthera explodens* Naudin, called 'fat baby') is cultivated locally in Cameroon at altitudes of 1500–2000 m as a fruit vegetable. It differs notably from *Cyclanthera pedata* in its explosively dehiscent, small fruits (2–4 cm long).

Ecology *Cyclanthera pedata* is fairly tolerant of cold and cultivated in the tropics at altitudes of 2000–3000 m.

Management Propagation is by seed. Plants are spaced at 90 cm × 90 cm. They have to be staked. Fruits are harvested from about 3 months after planting. Plants usually remain productive with abundant fruiting for several months. Harvesting is preferably done when the fruits are full-sized but still immature.

Genetic resources and breeding Interest in *Cyclanthera pedata* is mainly in the Americas and India, where commercial cultivars are marketed.

Prospects In highland areas in tropical Africa *Cyclanthera pedata* certainly has a future as a vegetable crop. Products based on a fruit extract are marketed in the United States and western Europe as a herbal medicine against high cholesterol levels, and demand might well increase.

Major references Jeffrey, C., 1967; Montoro, P. et al., 2001; National Research Council, 1989; Rubatzky, V.E. & Yamaguchi, M., 1997; van den Bergh, M.H., 1993.

Other references Cucurbit Network, 2003; Huxley, A., 1992a; Jeffrey, C., 1980; Keraudren, M., 1967.

Authors C.H. Bosch

CYNANCHUM SCHISTOGLOSSUM Schltr.

Protologue Journ. Bot. 33: 271 (1895).

Family Asclepiadaceae (APG: Apocynaceae)

Synonyms *Cynanchum brevidens* N.E.Br. (1895), *Cynanchum vagum* N.E.Br. (1895), *Cynanchum dewevrei* De Wild. & T.Durand (1900).

Origin and geographic distribution *Cynanchum schistoglossum* is distributed in southern Africa from Kenya, Burundi and DR Congo south to Angola and South Africa.

Uses In Malawi the leaves of *Cynanchum schistoglossum* are eaten raw or cooked as a side-dish vegetable, usually with salt added. The product is well liked and commonly used in the rainy season.

Properties No information is available on the phytochemistry of *Cynanchum schistoglossum*. Cynanchotoxin or vincetoxin are sometimes present in the leaves and roots of other *Cynanchum* species (e.g. in *Cynanchum africanum* (L.) Hoffsgg. and *Cynanchum ellipticum* (Harvey) R.A.Dyer), causing cynanchosis ('krampsiekte') in livestock in South Africa.

Botany Perennial herb up to 3 m tall, with woody rhizome; stem twining, strongly branched, containing latex. Leaves opposite, simple; petiole 1–2.5 cm long; blade ovate-lanceolate, 3.5–6 cm × 1.5–3.5 cm, base usually cordate, apex acute to acuminate, margin entire, sparsely covered with erect trichomes. Inflorescence a helicoid cyme, 5–20-flowered. Flowers bisexual, regular, 5-merous, musky scented; pedicel 3–8 mm long; calyx with triangular lobes, c. 1 mm × 0.5 mm; corolla cup-shaped, 1–3.5 mm long, white to yellow-green, lobes lanceolate, incurved; corona cup-shaped, c. 1.5 mm long, white, dentate at apex; stamens with very short free filaments, anthers winged and with connective appendage; ovary superior, stylar head depressed conical. Fruit consisting of a pair of fusiform, brown, glabrous follicles, each one 5–5.5 cm × 5–6 mm. Seeds ovoid, c. 5 mm × 4 mm, pale brown, at apex bearing a coma of hairs 2–2.5 cm long.
The genus *Cynanchum* comprises about 250 species worldwide. The major centre of diversity in Africa is Madagascar with approximately 70 species, minor centres of diversity are eastern Africa, the Horn of Africa and southern Africa with 10–15 species each. *Cynanchum schistoglossum* is the most variable *Cynanchum* species on the African mainland. Corona dentation and degree of fusion differ considerably among populations. The very

small flowers are characteristic for the species.

Ecology *Cynanchum schistoglossum* grows in forest margins, thickets and grasslands, often near water, but also along roadsides and in disturbed localities, from sea-level up to 1800 m altitude. It is found flowering year-round with a peak between April and October.

Genetic resources and breeding In southern Africa *Cynanchum schistoglossum* occurs locally, but is not rare or endangered.

Prospects The nutritive value of *Cynanchum schistoglossum* leaves and possibilities for its cultivation need more investigation.

Major references Liede, S., 1993; Liede, S., 1996; Williamson, J., 1955.

Other references Watt, J.M. & Breyer-Brandwijk, M.G., 1962.

Authors P.C.M. Jansen

CYPHOSTEMMA ADENOCAULE (Steud. ex A.Rich.) Wild & R.B.Drumm.

Protologue Fl. Zamb. 2(2): 473 (1966).

Family Vitaceae

Synonyms *Cissus adenocaulis* Steud. ex A.Rich. (1847).

Vernacular names Mwengele (Sw).

Origin and geographic distribution *Cyphostemma adenocaule* is widespread in tropical Africa from Senegal east to Eritrea and south to Angola, Malawi and Mozambique.

Uses The leaves and fruits of *Cyphostemma adenocaule* are commonly eaten as a vegetable or in soup in Ghana, DR Congo, Kenya and Uganda. In Uganda the leaves are boiled with beans, pigeon peas, cowpeas, groundnut or sesame. Both fruits and leaves have an acid, slightly acrid taste. The fruit is eaten raw in Côte d'Ivoire and Tanzania. The boiled roots are eaten in Ethiopia, and in Uganda sliced, dried and pounded roots are stored for famine periods.

There are many medicinal uses recorded for *Cyphostemma adenocaule*. Leaf sap is used to cure ophthalmia (DR Congo and Tanzania) and it is applied to cuts (Tanzania). Leaves are chewed to remedy a sore throat (Tanzania), and macerated leaves are mixed with honey as a cough treatment (Tanzania). Leaves heated over a fire are applied as a compress to reduce swellings (East Africa). Leaves are applied to the chest to cure pneumonia (East Africa) and an infusion of the leaves is taken as a purgative and to treat swollen abdomen. Macerated roots are taken against tapeworm (DR Congo). The root has been used to treat malaria. A paste made of the roots is applied topically to draw abscesses and reduce swellings in northern Ghana, Gabon and East Africa. Water in which roots have been boiled is drunk to treat syphilis, abdominal pain (related to pregnancy or not) and to prevent abortion. Root and leaf are prescribed against diarrhoea with blood.

Field tests were carried out in Uganda with *Cyphostemma adenocaule* as a trap crop for *Taylorilygus vosseleri*, an insect pest of cotton. When treated with insecticide to prevent the development of large populations of the pest, *Cyphostemma adenocaule* gave considerable protection to the cotton crop. Leaves crushed in water are used as an insecticide against chicken lice. In Kenya cattle like to browse it and people cut the stems to obtain drinking water. In Tanzania a fibre is obtained from the bark and string is made out of it. Dried stems are used for hut building in Uganda.

Properties The root is said to contain tannin. Leaves and fruits contain oxalic acid that is responsible for the acrid taste. No details are available on the chemical composition of *Cyphostemma adenocaule*. Several other *Cyphostemma* species used in traditional medicine in South Africa have been investigated, revealing the presence of compounds with anti-inflammatory, antimicrobial and antitumour activities.

Botany Perennial herb climbing or scrambling with leaf-opposed, branched tendrils; roots tuberous; stem slender, up to 3(–6) m long. Leaves alternate, pedately 5–7(–11)-foliolate; stipules ovate to oblong-ovate, up to 6–10 mm long, often red, persistent; petiole 1–5.5(–9.5) cm long; leaflets elliptical, ovate or broadly ovate, up to 11.5 cm × 7.5 cm, base cuneate to cordate, apex acuminate or acute. Inflorescence an irregular, lax, corymbose cyme 2–15 cm long. Flowers bisexual, 4-merous; calyx entire; petals narrowly oblong-triangular, up to 4 mm long. Fruit a fleshy berry up to 11 mm × 7 mm, usually deflexed, red to purplish black, 2–4-seeded. Seeds ellipsoid to ovoid, very slightly reniform, up to 8 mm long.

The genus *Cyphostemma* is closely related to *Cissus* and comprises about 250 species, almost all of them restricted to sub-Saharan Africa and Madagascar. Many *Cyphostemma* species are used in traditional medicine. *Cyphostemma adenocaule* is very variable, especially in the density of the indumentum. Sterile plants closely resemble *Cayratia gracilis* (Guill. & Perr.) Suess., but the stipules are caducous in

the latter.

Ecology *Cyphostemma adenocaule* is widespread in savanna and is found in gallery forests and fallow land as well.

Management Although it has been reported that *Cyphostemma adenocaule* is cultivated in Ethiopia, leaves and roots are normally collected from the wild. In Uganda leaves are collected during the rainy season. Dry roots can be stored for 1–2 months.

Genetic resources and breeding Because it is widespread and in many regions common *Cyphostemma adenocaule* does not seem to be threatened by genetic erosion.

Prospects In view of the use as a vegetable and the wide range of medicinal uses, research into the phytochemistry and cultivation technology is desirable.

Major references Burkill, H.M., 2000; Katende, A.B., Ssegawa, P. & Birnie, A., 1999; Kokwaro, J.O., 1993; Stride, G.O., 1969; Verdcourt, B., 1993.

Other references Lin, J. et al., 1999; Opoku, A.R. et al., 2000; Vollesen, K., 1989b; Watt, J.M. & Breyer-Brandwijk, M.G., 1962; Zemede Asfaw & Mesfin Tadesse, 2001.

Authors C.H. Bosch

DAUCUS CAROTA L.

Protologue Sp. pl. 1: 242 (1753).

Family Apiaceae (Umbelliferae)

Chromosome number $2n = 18$

Vernacular names Carrot (En). Carotte (Fr). Cenoura (Po). Karoti (Sw).

Origin and geographic distribution It is generally assumed that the eastern, purple-rooted carrot originated in Afghanistan in the region where the Himalayan and Hindu Kush mountains meet, and that it was domesticated in Afghanistan and adjacent regions of Russia, Iran, India, Pakistan and Anatolia. Purple carrot, together with a yellow variant, spread to the Mediterranean region and western Europe in the 11–14th centuries, and to China, India and Japan in the 14–17th centuries.

The western, orange carrot probably arose in Europe or in the western Mediterranean region through gradual selection within yellow carrot populations. The Dutch landraces Long Orange and the finer Horn types, first described in 1721, were an important basis for the western carrot cultivars grown at present all over the world. They have now largely replaced the eastern types because of superior taste and

Daucus carota – planted

nutritional value, and can also be found throughout Africa.

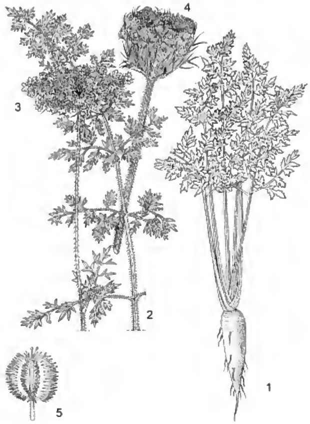
Uses The swollen taproot of *Daucus carota* is an important market vegetable, also in tropical areas. The roots are consumed raw or cooked, alone or in combination with other vegetables, as an ingredient of soups, dishes (e.g. couscous), sauces, juices and in dietary compositions. Large coarse roots are also used as fodder. Young leaves are sometimes eaten raw or used as fodder. In Ethiopia fruits are used against tapeworm. Essential oil extracted from the seed is used for flavouring. Carotene is extracted from the root and used to colour margarines and is added to hen feed to modify egg-yolk colour.

Production and international trade World carrot production increased from 13 million t in 1992 to 21 million t in 2002. Total area under carrot cultivation in 2002 was about 990,000 ha, with China 370,000 ha, Commonwealth of Independent States (including the Russian Federation) 171,000 ha, European Union 76,000 ha, eastern Europe and the Balkan 58,000 ha, the Americas 104,000 ha and Africa 80,000 ha (including North Africa 38,000 ha). Carrots are widely grown during the dry season in the (semi-)arid zones of West and Central Africa and in the highlands of East and southern Africa. The estimated area in Nigeria is 27,000 ha, in Kenya 5000 ha; statistics are not available for other countries. Occasionally, carrots imported from Europe (Belgium) are found in city markets in West Africa, e.g. in Abidjan (Côte d'Ivoire).

Properties Carrots (orange, young, raw, ends trimmed, edible part 87%) contain per 100

g edible portion: water 88.8 g, energy 126 kJ (30 kcal), protein 0.7 g, fat 0.5 g, carbohydrate 6.0 g, dietary fibre 2.4 g, Ca 34 mg, Mg 9 mg, P 25 mg, Fe 0.4 mg, Zn 0.2 mg, carotene 5.33 mg, thiamin 0.04 mg, riboflavin 0.02 mg, niacin 0.2 mg, folate 28 µg, ascorbic acid 4 mg (Holland, B., Unwin, I.D. & Buss, D.H., 1991). Orange carrot is a rich source of carotenoids (provitamin A).

The colour of eastern, purple carrots is caused by the anthocyanins in the root; in the western orange carrot the anthocyanins are replaced by carotene and carotenoids. Some Japanese cultivars with red flesh are rich in lycopene. Sugars, esters, terpenoids and other volatile compounds influence the flavour of raw carrots. Carrots grown under cool conditions are generally sweeter than those grown under high temperatures. An astringent taste of carrots is caused by a high terpolene content in combination with a low percentage of sugars. The bitter taste of carrots after long storage is caused by the conversion of phenols into isocoumarins (mainly 6-methoxymellein) under the influence of exogenous ethylene. These compounds are often a reason for consumer rejection of carrot products and a major problem for vegetable processors. The seed contains an essential oil with notes comparable to the root. The main components of the oil are the sesquiterpene alcohol carotol, daucol and the sesquiterpene β-bisabolene.



Daucus carota – 1, habit of cultivated plant; 2, part of leaf; 3, inflorescence; 4, infructescence; 5, fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

Description Annual or biennial erect herb up to 50 cm tall at the mature vegetative stage and up to 150 cm tall when flowering; taproot fleshy, straight, conical to cylindrical, 5–50 cm long and 2–5 cm in diameter at top, orange (most common), reddish violet, yellow or white. Leaves in a rosette at base of plant, but alternating on flowering stems, 2–3-pinnate; stipules absent; petiole long, sheathed at base, petiole and rachis pilose; segments divided into oblong to lanceolate or linear ultimate lobes. Inflorescence a terminal, compound umbel with numerous unequal rays, strongly contracted in fruit; involucral bracts 7–13, pinnatipartite or pinnatisect, with linear lobes. Flowers mainly bisexual, but male flowers present in addition to bisexual flowers, often 1–few dark purple sterile flowers present in the centre of umbel, c. 2 mm in diameter, 5-merous; pedicel 0.5–1.5 cm long; calyx with small teeth or absent; petals free, white or pinkish, often enlarged in exterior flowers of umbel; stamens free; ovary inferior, bristly hairy, 2-celled, styles 2. Fruit an oblong-ovoid schizocarp 2–4 mm long, at maturity splitting into two 1-seeded mericarps, primary ridges ciliate, secondary ridges with hooked spines. Seedling with epigeal germination; taproot long, thin; hypocotyl 0.5–1.5 cm long, epicotyl absent; cotyledons linear, leafy; first true leaves pinnate.

Other botanical information *Daucus* comprises about 20 species occurring mainly in the Mediterranean region. Wild *Daucus carota* is widespread in Europe and western Asia, and occurs also in northern Africa (Morocco, Algeria, Tunisia) and locally in tropical Africa (Eritrea, Ethiopia), at higher altitudes. Elsewhere in tropical Africa it is occasionally naturalized after escape from cultivation; this is also the case in other parts of the world, e.g. in North America, where it is now locally a common and noxious weed.

Daucus carota is a complex, very variable species. The complex has been subdivided into a dozen subspecies, 1 of these for cultivated carrot (subsp. *sativus* (Hoffm.) Arc.). However, for cultivated taxa it is better to classify into cultivar groups directly below the species level.

There are two main groups of cultivated carrot, based on root and leaf morphology:

- The eastern (anthocyanin) carrot: root branched, yellow, reddish-purple to purple-black, rarely yellowish-orange; leaves slightly dissected, greyish-green, pubescent; flowering in the first year.
- The western (carotene) carrot: root unbranched, yellow, orange or red, occasionally white; leaves strongly dissected, bright green, sparsely hairy; normally biennial, but often annual in tropical regions.

At present the western carrot is by far the most important, although the eastern carrot is still cultivated in some Asian countries. Three main groups of western (carotene) carrot cultivars arose by selection in the 19th and early 20th centuries in Europe and the United States:

- Early Short: 3–8 cm long globular-shaped roots, fine foliage; cultivars include 'Grelot', 'French Forcing', 'Parisian Market'.
- Early Half-Long: 10–20 cm long cylindrical to conical roots, fine to medium foliage; cultivars include 'Amsterdam Forcing', 'Nantes', 'Vertou', 'Touchon', 'Sitan'.
- Late Half-Long: 12–25 cm long conical and shouldered, stump or pointed roots, medium to large foliage, productive; cultivar types include 'Chantenay' (short), 'Royal Chantenay' (long), 'Danver', 'Autumn King', 'Berlicum' and 'Imperator'. 'Kuroda', developed around 1950, also belongs to this group; it combines an orange internal colour with heat tolerance.

In all groups many open-pollinated and F_1-hybrid cultivars have been developed, mostly by private seed companies in Europe, the United States and Japan. The majority of carrot cultivars are bred for temperate climates. When grown under hot conditions, these are less productive, often more affected by diseases and have poorer internal colour than cultivars developed especially for warm climates, e.g. 'Kuroda', 'Brasilia', 'Tropical Nantes' and some local selections in Africa and Asia. Popular cultivars in Africa are 'Nantes', 'Chantenay' and 'Kuroda'. In the Kenyan highlands cultivars producing baby carrots (e.g. 'Minicor', 'Orange Finger' and 'Sucrum') are produced for the export market.

Cultivated carrot crosses readily with wild carrot, which occurs naturally in Europe, western Asia and northern Africa, and which is naturalized in other regions, e.g. North America. Wild carrot has to be rigorously removed from seed production fields to prevent white-rooted and prematurely bolting plants in a carrot crop (white roots and annual habit are dominant over orange roots and biennial habit). Most other wild *Daucus* species are crossable with the cultivated carrot.

Growth and development Carrot seed will remain viable (70–80% germination) for 6–7 years when stored dry (moisture content 9%) at temperatures below 18°C. First appearance of seedlings is 9–12 days after sowing. The first 4 true leaves are formed at 4–5-day intervals, starting 3–4 weeks after sowing; for subsequent leaves the interval increases gradually to 15–18 days. A thin taproot grows down vertically to 20–25 cm, and 30–40 days after germination it starts swelling and gradually turning orange (in carotene carrots) from the hypocotyl part of the stem downwards. About 80% of all carbohydrates produced in the plant are diverted to the root during this stage of development.

The roots are mature 60–120 days after sowing according to the type of cultivar and growing conditions. The generative phase is induced by low temperatures. Carrot plants become sensitive to vernalization after the formation of at least 8 leaves. The bolting-resistant cultivars of higher latitudes require 5–12 weeks at 2–6°C to induce bolting. Local cultivars grown in the tropics show bolting when the night temperatures drop below 16°C. When flower induction has taken place the generative phase is accelerated by long days. First a new rosette of leaves is formed followed by elongation of the flowering stalk and first flowering 3 months later. Flowering may last for one month, starting with the primary umbel.

Carrot is predominantly outbreeding due to protandry. Insects such as bees and flies, attracted by abundant nectar, effect cross-pollination. The stigma becomes receptive 2–3 days after pollen dehiscence. Petals drop soon after fertilization and the fruits are mature 40–50 days later.

Ecology Supposedly wild (or naturalized) *Daucus carota* plants occur in Eritrea and Ethiopia at 1800–2100 m altitude.

In their adaptation to the northern latitudes of Europe, carrots became biennial. Long days during the vegetative phase before vernalization do not cause bolting. They require vernalization at low temperatures to induce flowering. Carrots adapted to tropical and subtropical latitudes respond to long days by bolting even before the roots have properly thickened.

Carrots are mostly cultivated as a cool season crop. High soil temperatures, in excess of 25°C,

induce slow growth rates, fibrous roots and low carotene content. For economic yields, carrots should be grown in tropical regions at altitudes above 1200 m or during the cool winter months in the subtropics. Early-maturing carrot cultivars may grow in the lowlands, but yields will be low and roots will have a poor colour. Optimum air temperatures are 16–24°C. Soils should be well drained, fertile and of a sandy texture. Heavy clay soils may induce malformed and twisted roots and harvesting will be difficult. Optimum pH is 6.0–6.5. A regular supply of water is essential to obtain smooth and even roots. Flowering and seed set are successful only in fairly dry climates with mean daily temperatures below 20°C.

Propagation and planting Seed multiplication at high latitudes with cold winters is based on stored and vernalized mature or young roots (stecklings) replanted in the field in spring (the root-seed method). In areas with mild winters and early snow cover, seeds are sown in late summer and the plants are left to overwinter in the field. These will bolt in spring and the seed-seed cycle is completed in 12–13 months. Carrot cultivars adapted to tropical regions have low vernalization requirements and can be propagated in highlands above 1200 m or during the cool period in arid and semi-arid regions. Carrot growers in such regions may maintain their cultivars by selecting the best mature roots and replanting them in a part of the field. Bolting and seed set soon follow.

The 1000-seed weight is 0.6–2.2 g. Seeds are sown, often mixed with sand, 1 cm deep in closely-spaced drills on finely prepared beds of soil cultivated to a depth of at least 30 cm. Plant densities range from 100 per m^2 for large-rooted processing carrots, 175 per m^2 for most fresh-market types to 250 per m^2 for small-rooted baby carrots (4–8 kg seed per ha). Lower densities of 10–50 plants per m^2 are applied in seed production fields. For hybrid seed production 8 rows of a female parent inbred line are alternated with 2 rows of a male one. Seed yields are increased significantly by placing beehives near the field during flowering. In-vitro propagation of carrots is easy and although researchers have experimented with 'artificial seed' in gel coating, this is too costly for practical application.

Management Crop rotation is essential to reduce soilborne diseases and pests. Mulching after sowing is recommended to encourage germination. Seedlings may be earthed-up when roots start swelling to keep them cool and prevent green tops. In hot weather, light overhead shade is beneficial. Irrigation during dry spells is necessary to prevent irregular root development.

The nutrient removal of a crop of 20 t of fresh carrots is N 85 kg, P 20 kg, K 110 kg, Ca 60 kg and Mg 15 kg. Optimum fertilizer application will depend on soil nutrient reserves and expected yield level, but it is clear that carrots require relatively high doses of K fertilizer. Application of N 75–150 kg/ha, P 50–100 kg/ha and K 50–200 kg/ha is usually adequate. High N applications tend to cause excessive growth of foliage. Carrots are sensitive to high Cl concentrations and more susceptible to diseases at low soil pH. Liming or the use of Ca-containing fertilizers is recommended when pH is below 5.5. Well-decomposed organic manures are beneficial when applied with moderation (10–20 t/ha). Fresh organic matter, e.g. from a leguminous crop, can be detrimental to the carrot crop.

Diseases and pests The major diseases in tropical carrot production are leaf blights (*Alternaria dauci* and *Cercospora carotae*) and root-knot nematodes (*Meloidogyne hapla* and other *Meloidogyne* spp.). 'Kuroda' has strong foliage with a remarkable field tolerance to *Alternaria* leaf blight, which may completely destroy the foliage of cultivars introduced from Europe. Crop loss by root-knot nematodes may be kept under control by crop rotation, e.g. with cereals and by the application of organic manure. Nematode infested soils can be treated by solarization, or with soil fumigants, although this is expensive and hazardous.

Other diseases are powdery mildew (*Erysiphe polygoni* and *Erysiphe heraclei*), bacterial blight (*Xanthomonas campestris* pv. *carotae*), black spot on roots (*Alternaria radicina*), and purple root rot (*Helicobasidium brebisonii*). Various root rots occur before or during storage, often after mechanical damage or as secondary pathogens (*Botrytis cinerea*, *Fusarium* spp., *Sclerotinia sclerotiorum*, *Pythium violae* and related spp., *Erwinia carotovora*). Root diseases are more severe in heavy soils with a poor structure. A total of 14 virus diseases have been identified in carrots, the most important being carrot red leaf virus (CaRLV). Carrot can be affected by aster yellows, a phytoplasma.

The most noxious pest of carrot in temperate areas is carrot root fly (*Psila rosae*) to which some degree of resistance has been found in

'Sitan' and in the wild species *Daucus capillifolius* Gilli from Libya. The lygus bug (*Lygus hesperus* and *Lygus elisus*) on seed crops, aphids (e.g. *Cavariella aegopodii*) as vectors of virus diseases, the leafhopper *Macrosteles fascifrons* as vector of aster yellows, carrot weevil (*Listronotus oregonensis*) and other foliage pests have all been reported in carrot, but probably the only pest which may cause serious crop losses in Africa is army worm (*Spodoptera* spp.).

Harvesting Carrot is mostly harvested manually by pulling up the roots at the leaves. This requires strong and healthy foliage. Mechanical harvesting (in Europe, United States) is also based on pulling up by the foliage, or first topping the leaves and then lifting the carrots as in potato harvesting. In Africa carrots are usually ready for harvesting 60–85 days after sowing. Mature roots should be orange-coloured internally down to the blunt tip. In seed production fields the primary umbels are sometimes harvested prior to the main seed crop, as these ripen earlier and produce the largest seeds.

Yield World average yield in 2002 was 21 t/ha of fresh carrot roots. In tropical Africa yields vary from 8–12 t/ha; higher yields are obtained in East Africa above 1500 m altitude. In Europe and the United States 30–120 t/ha can be harvested, depending on the type of cultivar and management. Marketable yield is also much influenced by plant density and time of harvest. Root weight and uniformity are closely related to seed size and quality.
Seed yields are 800–2000 kg/ha for open-pollinated and 700–1200 kg/ha for F_1-hybrid cultivars.

Handling after harvest Carrots bunched with leaves will store up to 3 weeks in a cool place, but can remain in good condition for 100–150 days when topped (foliage removed) and stored at 1–4°C with 95–100% relative humidity. Carrots should be stored separately from other vegetables to prevent development of a bitter flavour induced by ethylene. Generally carrots store better when the dry matter content is high, when they are grown on soils with low organic matter content, when they are mature and harvested under moist conditions, undamaged and free of diseases and pests. Carrots may be graded according to weight classes: A (< 50 g), B (50–200 g), C (200–400 g) 400 g). Carrots for the export market are carefully washed after removal of damaged roots, graded into different sizes according to the market requirement and packaged in perforated polythene bags. Small-scale farmers in Africa simply pack topped carrot roots in sacks for transportation to the local markets. This may cause considerable post-harvest losses.

Genetic resources The genetic basis of modern orange carrot cultivars is rather narrow, considering that they are mostly derived from a few 18th-century Dutch cultivars. Exploitation of the genetic variation existing in wild *Daucus* germplasm in the Mediterranean and south-western Asian regions started only recently. Germplasm collections of *Daucus carota* and related species, totalling some 5600 accessions, are available in Europe (United Kingdom, France, Netherlands), Russia, United States and Japan.

Breeding Before 1960 breeding methods were based on mass selection in open-pollinated populations, but F_1-hybrids with greater uniformity are now increasingly replacing the older cultivars, particularly in Europe, the United States and Japan. Seed production of F_1-hybrid cultivars is based on cytoplasmic male sterility of one of the parent inbred lines. Two types are used: the brown anther type, in which the anthers degenerate before anthesis, based on S-cytoplasm and at least two recessive genes with complementary action, and the petaloid type, in which the anthers are replaced by 5 additional petals, based on S-cytoplasm and at least two dominant genes with complementary action. The development and maintenance of inbred lines is complicated by severe loss of plant vigour after a few generations of inbreeding.
Main breeding objectives are improvements in total yield of fresh roots but also seed (F_1-hybrids in particular), growth rate and earliness, uniformity of root size and shape, lightly shouldered tops without greening, small core and no internal greening, dark orange external and internal colour, smooth skin and absence of large laterals, resistance to cracking and breaking of the root during harvesting and post-harvest handling, taste, flavour, texture, carotene content, strong foliage, non-bolting, resistance to diseases and pests and heat tolerance for warm climates. The most popular cultivars are somewhat conical, as these break less easily during harvesting.

Prospects Carrot will be of increasing importance in tropical Africa. It is a valuable vegetable to be promoted in areas with vitamin A deficiency in human nutrition (where no red palm oil is used as kitchen oil). Adaptation to

lowland tropical climates will remain limited. Genetic transformation is relatively easily achieved in carrot and offers interesting opportunities for developing cultivars resistant to important diseases and pests, which are difficult to realize by conventional breeding. Transgenic carrot plants also appear to be capable of producing recombinant proteins used for medicinal purposes in large quantities and at low costs.

Major references Banga, O., 1963; Heywood, V.H., 1983; Hoehn, E., Schaerer, H. & Kuensch, U., 2003; Kahangi, E.M., Chweya, J.A. & Akundabweni, L.S.M., 1996a; Peterson, C.E. & Simon, P.W., 1986; Quagliotti, L., 1967; Rubatzky, V.E., Quiros, C.F. & Simon, P.W., 1999; Rubatzky, V.E. & Yamaguchi, M., 1997; Takaichi, M. & Oeda, K., 2000; van der Vossen, H.A.M. & Sambas, E.N., 1993.

Other references Banga, O. & de Bruyn, J.W., 1968; Czepa, A. & Hofmann, T., 2003; Hedberg, I. & Hedberg, O., 2003; Holland, B., Unwin, I.D. & Buss, D.H., 1991; Kahangi, E.M., Chweya, J.A. & Akundabweni, L.S.M., 1996b; Porceddu, A. et al., 2000; Shinohara, S., 1984.

Sources of illustration van der Vossen, H.A.M. & Sambas, E.N., 1993.

Authors H.A.M. van der Vossen & E. Kahangi

Based on PROSEA 8: Vegetables.

DICTYOSPERMA ALBUM (Bory) Scheff.

Protologue Ann. Jard. Bot. Buitenzorg 1: 157 (1876).

Family Arecaceae (Palmae)

Synonyms *Areca alba* Bory (1804), *Dictyosperma aureum* H.Wendl. & Drude (1878), *Dictyosperma furfuraceum* H.Wendl. & Drude (1878).

Vernacular names Hurricane palm, white barbel palm, yellow barbel palm, princess palm (En). Palmiste blanc, palmiste bon, palmiste de l'île Ronde (Fr).

Origin and geographic distribution *Dictyosperma album* is endemic to Réunion and Mauritius.

Uses *Dictyosperma album* is valued for its excellent palm heart. It is widely grown as an ornamental in the tropics and subtropics. In Mauritius a root decoction is used as a diuretic.

Botany Slender palm up to 20 m tall, with trunk up to 16 cm in diameter. Leaves 10–20 in crown, arranged spirally, pinnately compound; sheath 70–110 cm long, with grey tomentum, petiole 15–45 cm long, rachis 2–2.5 m long; leaflets 50–70 on each side of the rachis, median leaflets 60–75 cm × 3–5 cm. Inflorescence up to 1.1 m long; lowest bract 0.4–1 m long; peduncle 4–7 cm long, with grey-brown scaly hairs; branches up to 40, 20–75 cm long, hanging, glabrous. Flowers unisexual, 3-merous, 5–8 mm long; male flowers yellow to brown, with 6 stamens and rudimentary pistil; female flowers with superior, ovoid, 1-celled ovary and 3 minute rudimentary stamens. Fruit an ovoid-ellipsoid drupe 1.5–2 cm × 1 cm, very dark purple or black, 1-seeded. Seed ovoid-ellipsoid, c. 1 cm long, irregularly ribbed; endosperm ruminate.

Dictyosperma comprises a single species. Three varieties are distinguished: var. *album*, the white hurricane palm; var. *aureum* Balf.f., the golden hurricane palm, generally less than 10 m tall and with a distinct yellow or orange stripe on the lower side of the petiole and rachis; and var. *conjugatum* H.E.Moore & L.J.Guého, with a short sturdy stem up to 5 m tall, red to brown male flowers and the tips of the leaflets staying attached to one another for a long time, giving it a characteristic appearance. *Dictyosperma album* is a medium fast grower.

Ecology *Dictyosperma album* grows at low elevations generally up to 600 m altitude. In cultivation, light shade or full sun and well-drained soils are recommended. It is salt and wind tolerant.

Management The three varieties of the hurricane palm are cultivated in the Mascarene Islands and elsewhere. In Réunion tree growth has been investigated on-farm under several management regimes, especially with regard to weed control.

Genetic resources and breeding *Dictyosperma album* var. *album* occurs in the wild with a total of about 30 individuals in Mauritius and Réunion. No natural regeneration has been observed recently. This variety is extensively cultivated for the palm heart in Mauritius and Réunion, all stocks originating from Réunion. The Conservatoire Botanique National de Mascarin in Réunion and the Sir Seewoosagur Ramgoolam Botanic Garden in Mauritius have collections of var. *album*. Less than 10 individuals of var. *aureum* are known from Rodrigues, and all are in unprotected environments. Seedlings have been grown at the Solitude Nursery, Rodrigues, and near to 300 seedlings have been replanted in the two

main reserves of the island. Var. *conjugatum* is endemic to Round Island, off the north-east coast of Mauritius, and only one wild adult individual is known. Seedlings have been grown by the National Parks and Conservation Service and 50 of these have been introduced to the rat-free Ile aux Aigrettes, off the east coast of Mauritius. The Sir Seewoosagur Ramgoolam Botanic Garden in Mauritius has extensive collections of this variety as well.
All three varieties are indicated as critically endangered, but they do not feature on the IUCN Red List.

Prospects *Dictyosperma album* is being planted experimentally for the palm heart. It takes a long time before the trees are sufficiently mature for harvesting the palm heart, but in the meantime they may provide a source of seeds which can be exploited commercially. This could provide the farmers with an additional source of income before the trees are cut for the palm heart. *Dictyosperma album* is an attractive ornamental palm. Var. *conjugatum* with its peculiar leaves has great ornamental potential, but the sources of seed are limited.

Major references Gurib-Fakim, A., 2002; Maunder, M. et al., 2002; Moore, H.E. & Guého, L.J., 1984; Normand, F., 1999; Tuley, P., 1995; Uhl, N.W. & Dransfield, J., 1987.

Other references Gray, M., 2003; IUCN, 2003; Palmarium, 2003.

Authors W.J. van der Burg

DIGERA MURICATA (L.) Mart.

Protologue Beitr. Amarantac.: 77, no 2 (1825).

Family Amaranthaceae

Synonyms *Digera arvensis* Forssk. (1775), *Digera alternifolia* (L.) Asch. (1867), *Digera angustifolia* Suess. (1950).

Origin and geographic distribution *Digera muricata* is widespread in eastern tropical Africa (from Sudan and Ethiopia south to Tanzania), Madagascar and tropical and subtropical Asia (from Yemen to Afghanistan, Pakistan, India, Malaysia and Indonesia).

Uses Leaves and young shoots of *Digera muricata* are locally used as a vegetable, e.g. in Africa (Ethiopia, Kenya) and in India. In Kenya they are particularly popular as a cooked vegetable amongst coastal tribes. In India the leaves are made into curries or the entire plant is boiled in water and seasoned with salt and chilli. Sometimes *Digera muricata* is considered a famine food.
The flowers are rich in nectar which is sometimes sucked by children in Kenya. The whole plant is also commonly grazed as a forage, particularly by sheep and goats. In Senegal *Digera muricata* is used internally against digestive system disorders and in India seeds and flowers are used to treat urinary disorders.

Botany Annual herb up to 70 cm tall; stem simple or branched, subglabrous, ridged. Leaves alternate, simple; petiole up to 5 cm long; blade linear to ovate, 1–9 cm × 0.2–5 cm, base narrowed, apex acuminate, margin entire, subglabrous. Inflorescence a long-pedunculate (up to 14 cm long), axillary, spike-like bracteate raceme up to 30 cm long, each bract subtending a subsessile partial inflorescence with a central fertile flower and 2 sterile lateral flowers. Fertile flower with 2 firm, boat-shaped outer perianth segments 3–5 mm long and 2–3 inner, slightly shorter, hyaline segments; stamens usually 5, free or slightly connate at base; ovary superior, 1-celled, style filiform, up to 4 mm long, stigmas 2, divergent; lateral flowers consisting of accrescent antler-shaped scales. Fruit a subglobose, hard, indehiscent nutlet c. 2 mm in diameter, ridged, enclosed by the persistent perianth and falling together with the sterile flowers and bracteoles.
Digera comprises only 1 species. Based on the venation of the outer tepals 2 subspecies of *Digera muricata* have been distinguished: subsp. *muricata* with outer tepals 7–12-veined, mainly occurring in Asia, but also in eastern Africa and Madagascar, and subsp. *trinervis* C.C.Towns. with outer tepals 3–5-veined, mainly occurring in Africa. Based on hairiness of leaves and on form of scales in sterile flowers, several varieties have been distinguished in subsp. *trinervis*, of which var. *patentipilosa* C.C.Towns. seems most suitable as a leafy vegetable because it has large leaves.

Ecology *Digera muricata* is most common on disturbed and waste ground, but occurs in many kinds of habitat, from dry savanna and semi-desert to moist localities on deep clay and mud soils, from sea-level up to 1500 m altitude. It also occurs as a weed in fields, sometimes being troublesome.

Management *Digera muricata* is usually collected from the wild although in parts of Ethiopia (Konso region) and India it is also cultivated as a leaf vegetable and sold on local markets.

Genetic resources and breeding *Digera muricata* is widespread and not in danger of

genetic ersosion.

Prospects *Digera muricata* will most probably remain a leaf vegetable of only local importance.

Major references Freedman, R.L., 1998; Maundu, P.M., Ngugi, G.W. & Kabuye, C.H.S., 1999; Schippers, R.R., 2000; Seshadri, S. & Nambiar, V.S., 2003; Townsend, C.C., 1985.

Other references Cavaco, A., 1954a; Hauman, L., 1951a; Townsend, C.C., 2000.

Authors P.C.M. Jansen

DINOPHORA SPENNEROIDES Benth.

Protologue Hook., Niger Fl.: 355 (1849).

Family Melastomataceae

Chromosome number $n = 12$

Origin and geographic distribution *Dinophora spenneroides* occurs from Guinea to Angola, DR Congo and Rwanda.

Uses In Gabon and DR Congo the leaves of *Dinophora spenneroides* are collected from the wild and eaten as a substitute for *Hibiscus sabdariffa* L. The taste is acidulous. The fruit contains some sweet pulp which is eaten by children in Gabon. A leaf decoction is recommended for stomach problems, dysentery and haemorrhoids. In Gabon heated leaves are applied to ulcers and sprains, and eaten to treat stomach-ache. A leaf infusion is used against cough, loss of voice and laryngitis, and powdered leaves are applied to sores and wounds.

Botany Spreading shrub up to 4 m tall, with slender branches, quadrangular when young, later becoming terete, glabrescent. Leaves opposite, simple, those of the same pair usually unequal in size; stipules absent; petiole 1–10 cm long; blade ovate-oblong to lanceolate, 5–22 cm × 1.5–8 cm, base usually rounded-cordate, apex acuminate, margin serrate with mucronate teeth, densely short-pubescent above, glabrous below, with 5–7 prominent ascending veins and parallel transversal veinlets. Inflorescence a terminal, lax, hanging panicle up to 20 cm × 27 cm, consisting of cymes. Flowers bisexual, regular, 5-merous; pedicel 0.5–1.5 cm long, gradually enlarging into an obconical hypanthium; calyx tubular, 4–5 mm long, fleshy, with small teeth; petals ovate, c. 1 cm long, fleshy, pink or white; stamens 10, arranged in 2 whorls, filaments curved, anthers with a 2-lobed appendix at base, opening by an apical pore; ovary inferior, connate with hypanthium, many-celled, style sigmoid, thickened above, c. 1 cm long, ending in a small circular stigma. Fruit an ellipsoid to globose false berry c. 1.5 cm long, whitish, many-seeded. Seeds shell-shaped, c. 1 mm long.

Dinophora comprises a single species.

Ecology *Dinophora spenneroides* occurs in forest undergrowth, preferring more open locations, e.g. along paths and on former cultivation sites, from sea-level up to 2000 m altitude.

Genetic resources and breeding *Dinophora spenneroides* is widespread and not in danger of genetic erosion.

Prospects *Dinophora spenneroides* will remain a minor leaf vegetable of only local importance. Its nutritional and medicinal properties deserve investigation.

Major references Burkill, H.M., 1997; Jacques-Félix, H., 1983; Raponda-Walker, A. & Sillans, R., 1961.

Other references Keay, R.W.J., 1954c; Troupin, G., 1982.

Authors P.C.M. Jansen

DIOSCOREA PRAEHENSILIS Benth.

Protologue Hook., Niger Fl.: 536 (1849).

Family Dioscoreaceae

Synonyms *Dioscorea cayenensis* Lam. var. *praehensilis* (Benth.) A.Chev.

Vernacular names Bush yam, forest yam, white yam (En). Igname de brousse, igname sauvage (Fr).

Origin and geographic distribution *Dioscorea praehensilis* occurs wild from Guinea east to Ethiopia and south to Angola, Zambia, Malawi and Mozambique.

Uses The young shoots are eaten in Bas Congo (DR Congo). The flesh of the tuber is bitter and only eaten after careful preparation. In Gabon the tuber is only eaten when young and after long cooking. In northern Nigeria it is eaten as famine food. In Congo the boiled tuber is taken to accelerate childbirth, and sometimes to relieve rheumatism. In DR Congo an infusion prepared from the older stem is used to treat stomach complaints, urethral discharge and oedema.

Botany Dioecious climbing herb up to 15 m long; tuber up to 60 cm long, flesh white with yellow tinge, with bitter purple layer below the skin, armed with a crown of thorny roots; stem 1–2 cm in diameter, slightly ribbed longitudinally, spiny, often waxy, glabrous, purplish-green. Leaves opposite, occasionally alternate, simple; petiole 2.5–5 cm long; blade ovate to ovate-lanceolate, 4–10 cm × 3–5 cm, deeply cor-

date at base, acute at apex, entire, 5–7-veined; basal leaves often strongly reduced. Inflorescence an axillary spike; male ones 3–5 together, flexuous, 3–5 cm long; female ones 1–2 together, pendulous, 10–25 cm long. Flowers unisexual, perianth segments in 2 rows of 3, 1–1.5 mm long; male flowers with 6 stamens; female flowers with inferior, 3-celled ovary. Fruit a deeply 3-lobed capsule 2–2.5 cm × 3 cm, 3–6-seeded. Seeds winged all round, 1.5–2 cm long.
It has been suggested that *Dioscorea praehensilis* is one of the parents of the cultivated *Dioscorea cayenensis* Lam., together with other species of the section *Enantiophyllum* such as *Dioscorea abyssinica* Hochst. ex Kunth and *Dioscorea burkilliana* J.Miège.

Ecology *Dioscorea praehensilis* grows in forest, often secondary forest, and along forest margins up to 700(–1600) m altitude.

Management *Dioscorea praehensilis* has occasionally been taken into cultivation. The wild form has been to some extent genetically improved to produce longer tubers. In some cultivars the protective thorny armature of roots has been reduced to slender short spiny roots. The cultivation is like other yams; *Dioscorea praehensilis* is grown in well-weeded plots, often in mounds of soil and trained against a support.

Genetic resources and breeding *Dioscorea praehensilis* is quite common in West Africa. It is considered one of the wild relatives, or even one of the parents, of the cultivated *Dioscorea cayenensis* and therefore may be used as a source of resistance and other useful properties. The many genetically different populations are being studied.
Several living collections are kept in institutes in Ghana, Côte d'Ivoire, Togo, Benin and Nigeria. The seeds of *Dioscorea praehensilis* can be stored under gene bank conditions for long periods without deterioration. *Dioscorea* seed collections are kept in gene banks all over the world; large collections are maintained at IRD (Institut de Recherche pour le Développement), Montpellier, France and IITA, Ibadan, Nigeria.

Prospects As a vegetable *Dioscorea praehensilis* is of limited use and potential. It is important as a source of genetic variation in yam breeding work. Further genetic improvement to reduce the bitter constituents may render this yam more palatable and popular.

Major references Bouquet, A., 1969; Burkill, H.M., 1985; Coursey, D.G., 1976; Dalziel, J.M., 1937; Latham, P., 2002.

Other references Berthaud, J. et al., 1998; IPGRI, 2003; Malaurie, B., Pungu, O. & Trouslot, M.F., 1995; Miège, J. & Demissew Sebsebe, 1997; Okigbo, B.N., 1987; Okiy, G.E.O., 1962; Ongoiba Moussa, H., 1985; Raponda-Walker, A. & Sillans, R., 1961; Tostain, S. & Daïnou, O., 1998.

Authors W.J. van der Burg

DIPLAZIUM PROLIFERUM (Lam.) Thouars

Protologue Esquisse fl. Tristan d'Acugna: 35 (1808).

Family Dryopteridaceae

Chromosome number $2n = 82$

Synonyms *Asplenium proliferum* Lam. (1786), *Callipteris prolifera* (Lam.) Bory (1804), *Diplazium accedens* Blume (1828), *Callipteris accedens* (Blume) J.Sm. (1841), *Athyrium accedens* (Blume) Milde (1870).

Vernacular names Mother fern (En).

Origin and geographic distribution *Diplazium proliferum* is widespread in tropical Africa, from Guinea to Cameroon and Equatorial Guinea (Bioko), São Tomé et Principe, DR Congo and Madagascar.

Uses In Madagascar the young still enrolled fronds (croziers, fiddleheads) are eaten as a cooked vegetable. In South-East Asia the croziers as well as the bulbils present on the rachis are eaten boiled or steamed as a vegetable, or raw as a salad. *Diplazium proliferum* is widely planted as an ornamental.
The related *Diplazium esculentum* (Retz.) Sw. is the most important fern used for human food in the world. It does not occur in Africa.

Botany Large fern with erect rhizome covered with brown scales at apex. Leaves slightly leathery, clustered at apex of rhizome, producing bulbils and young plants all over the rachis; petiole 3–60 cm long, straw-coloured; lamina 60–200 cm long, pinnate; pinnae numerous, lanceolate, the lower ones slightly reduced, median pinnae alternate, 6–7 cm apart, shortly petiolate, 15–20 cm × 3–5 cm, truncate at base, apex abruptly narrowed into a long tip; lobes of pinnae rounded or emarginate at apex, denticulate; bases of pinnae proliferous, with young plantlets on the upper side. Sori linear, in a characteristic V-shaped arrangement following all veinlets of the lobes, usually 4–5, but up to 7 especially in West Africa. Indusia linear, attached along the vein. Spores with a few long folds above a papillate inner perispore.
Diplazium is often placed in *Woodsiaceae*, sometimes in *Athyriaceae*, families which are

included in *Dryopteridaceae* here. Some authors propose placing *Diplazium* in *Thelypteridaceae*. The genus is closely related to *Athyrium*, from which it would differ by only one chromosome (n = 40 and n = 41 respectively) even though the chromosome number n = 41 is not consistent in *Diplazium*. *Diplazium proliferum* and related species with anastomosing veins are sometimes placed in a separate genus *Callipteris*.

Ecology *Diplazium proliferum* grows in *Raphia* thickets and marshes.

Management *Diplazium* species are easily grown from spores. The bulbils can be detached and placed in the soil for rooting, or they can be left on the plant to develop into plantlets which can be simply detached and planted.

Genetic resources and breeding *Diplazium proliferum* is widespread and does not seem to be endangered. Although it is widely cultivated as an ornamental, it is not cultivated for use as a vegetable. No germplasm collections are known.

Prospects No special culinary merits are known of *Diplazium proliferum* and it seems unlikely that it has the potential to be grown and traded at a commercial scale. Its use as an ornamental remains important.

Major references Burkill, H.M., 2000; Decary, R., 1946; Hovenkamp, P.H. & Umi Kalsom, Y., 2003; Johns, R.J., 1991; Stevenson, D.W., 1984.

Other references Alston, A.H.G., 1959; Burrows, J.E. & Burrows, S.M., 2001; Faden, R.B., 1973; Holttum, R.E. & Roy, S.K., 1965; Jones, D.L., 1998; Manton, I., 1959; Tardieu-Blot, M.L., 1964b; Tryon, A.F. & Lugardon, B., 1990.

Authors W.J. van der Burg

DIPLOCYCLOS PALMATUS (L.) C.Jeffrey

Protologue Kew Bull. 15: 352 (1962).

Family Cucurbitaceae

Chromosome number $2n$ = 24

Vernacular names Lollipop climber, striped cucumber, native bryony (En).

Origin and geographic distribution *Diplocyclos palmatus* is widely spread in the Old World tropics including Madagascar. It occurs throughout sub-Saharan Africa, but is absent in most of West Africa and Somalia.

Uses The leaves of *Diplocyclos palmatus* are eaten as a vegetable in Kenya and in South-East Asia; young fruits and shoots are occasionally eaten as well in South-East Asia. In Kenya the roots are used as an antivenin and fruits and leaves to cure stomach-ache. In Thailand stems are used as an expectorant and fruits as a laxative, and in Nepal seeds as a febrifuge. *Diplocyclos palmatus* is grown in Kenya and Zimbabwe as a garden ornamental because of the decorative fruits.

Properties Dried leaves caused death in calves and ewes in Kenya. Galactose specific lectin activity was detected in the mucilaginous coat surrounding the seeds of *Diplocyclos palmatus*. The lectin is a single polypeptide chain containing 2% carbohydrate. Punicic acid, a trans fatty acid that is rare in plants, was isolated from *Diplocyclos palmatus*.

Botany Perennial, monoecious herb climbing by bifid tendrils; stem up to 6 m long, young stems spotted with darker green. Leaves alternate, simple; stipules absent; petiole 2–10 cm long; blade broadly ovate, palmately 5(–7)-lobed, up to 14 cm × 15 cm; base cordate; lobes narrowly elliptical or elliptical, margin sinuate-dentate. Inflorescence an axillary cluster, with usually both male and female flowers in same axil. Flowers unisexual, regular, 5-merous, corolla white to greenish-yellow; male flowers pedicellate, with 3 free stamens; female flowers subsessile, with inferior, 1-celled ovary, stigma 3-lobed. Fruit a subglobose, indehiscent berry 1.5–2.5 cm in diameter, solitary or clustered, red with silvery white longitudinal stripes.

Diplocyclos comprises 4 species, 3 of which are confined to Africa.

Ecology *Diplocyclos palmatus* occurs in different types of vegetation, but usually in wet localities, e.g. swampy forest, flood-plains and valleys, at altitudes up to 1800 m.

Genetic resources and breeding As *Diplocyclos palmatus* is widespread and hardly exploited, there seem to be no immediate threats of genetic erosion.

Prospects In view of the toxicity, promoting the consumption of *Diplocyclos* is hazardous. Further research into the chemical constituents is desirable.

Major references Anuradha, P. & Bhide S., 2002; Jeffrey, C., 1995; Keraudren-Aymonin, M., 1983; Mugura, G.M., 1970; Njoroge, G.N. & Newton, L.E., 2002; van den Bergh, M.H., 1993.

Other references Burkill, H.M., 1985; Jeffrey, C., 1962; Jeffrey, C., 1979.

Authors C.H. Bosch

DUOSPERMA CRENATUM (Lindau) P.G.Mey.

Protologue Mitt. Bot. Staatssamml. München 3: 602 (1960).

Family Acanthaceae

Synonyms *Hygrophila crenata* Lindau (1894), *Disperma parviflorum* (Lindau) C.B.Clarke (1899), *Disperma crenatum* (Lindau) Milne-Redh. (1933).

Origin and geographic distribution *Duosperma crenatum* is found in Kenya, Tanzania, Malawi, Zambia, Namibia, Zimbabwe and Mozambique.

Uses Young leaves of *Duosperma crenatum* are collected from the wild, chopped and cooked alone or mixed with other vegetables such as peas or amaranth leaves, and served with a staple food. Coconut milk or pounded groundnuts are often added. A leaf infusion is drunk by women for an easy delivery. *Duosperma crenatum* is also used as forage.

Properties Mature leaves of *Duosperma crenatum* which start to turn yellow are believed to be toxic to humans.

Botany Erect small shrub or perennial herb up to 1.2 m tall, with more or less quadrangular, pubescent stems arising from a woody rhizome. Leaves opposite, simple, almost sessile; blade elliptical, up to 8 cm × 4 cm, narrowed at both ends, margin entire in lower part, crenate to toothed in upper part, sparsely hairy. Inflorescence an axillary, dense, cymose fascicle, with small pale green bracts. Flowers bisexual, zygomorphic, 5-merous; calyx tubular, 6–9 mm long, lobes more or less connate; corolla tubular, 9–11 mm long, 2-lipped, white with purplish dots or lines in the throat; stamens 4; ovary superior, 2-celled, style with 2 unequal stigmoid branches. Fruit a flattened, ellipsoid capsule c. 8 mm long, shiny brown, 2-seeded. Seeds discoid, with hygroscopic hairs on the margin.

Duosperma comprises about 15 species and is confined to tropical Africa, but it is not well known. Most characteristic are its flattened-ellipsoid fruits with 2 seeds only.

Ecology *Duosperma crenatum* occurs in dry rocky bushland, at 300–1000 m altitude.

Genetic resources and breeding *Duosperma crenatum* is rather widespread and does not seem to be in danger of genetic erosion, although in some countries it is reported to be rare (e.g. in Kenya).

Prospects *Duosperma crenatum* will remain a minor leaf vegetable in the dry areas of East and southern Africa. Its nutritional and chemical composition require investigation.

Major references Burkill, I.H. & Clarke, C.B., 1899–1900; Ruffo, C.K., Birnie, A. & Tengnäs, B., 2002.

Other references Agnew, A.D.Q. & Agnew, S., 1994; Brummitt, R.K., 1974.

Authors P.C.M. Jansen

DYPSIS BARONII (Becc.) Beentje & J.Dransf.

Protologue J.Dransf. & Beentje, The palms of Madagascar: 198 (1995).

Family Arecaceae (Palmae)

Synonyms *Chrysalidocarpus baronii* Becc. (1906), *Neodypsis baronii* (Becc.) Jum. (1924).

Vernacular names Sugarcane tree, sugarcane palm (En).

Origin and geographic distribution *Dypsis baronii* is endemic to Madagascar.

Uses The palm heart of *Dypsis baronii* is reported to be an excellent vegetable; the fruits are also edible and sweet. *Dypsis baronii* is a very elegant palm and is grown in Antananarivo and other parts of Madagascar (and occasionally elsewhere) as an ornamental.

Botany Palm with sugarcane-like trunks clustering in clumps of 3–5, 2–8 m tall and up to 12(–22) cm in diameter; crown shaft up to 60 cm long, pale green to pale yellow. Leaves 4–8 in the crown, arranged spirally, pinnately compound; sheath up to 60 cm long, petiole up to 37(–53) cm long, rachis 50–120 cm long; leaflets 35–60 on each side of the rachis, dark green, basal leaflets threadlike, hanging, up to 1 m long, median leaflets stiff, up to 50 cm long. Inflorescence between or below the leaves, branched to 2 orders, arching; peduncle 25–60 cm long, reddish; bracts 4, up to 75 cm long; rachis up to 35 cm long, branches up to 25 cm long, pinkish to pale green, with both male and female flowers. Flowers unisexual, 3-merous; male flowers with 6 stamens and a rudimentary pistil; female flowers with superior, apparently 1-celled ovary and rudimentary stamens. Fruit an ellipsoid or subglobose drupe 1–2 cm × 1–1.5 cm, 1-seeded. Seed ellipsoid, c. 1 cm long, outside slightly grooved; endosperm ruminate.

Dypsis comprises about 140 species, all endemic to Madagascar except 2 occurring in Comoros and 1 on Pemba Island.

Some *Dypsis* species apparently related to *Dypsis baronii* have been reported as sources of palm heart: *Dypsis basilonga* (Jum. & H.Perrier) Beentje & J.Dransf., *Dypsis oreo-*

phila Beentje, and *Dypsis tsaratananensis* (Jum.) Beentje & J.Dransf. However, all these species are much more rare than *Dypsis baronii*.

Ecology *Dypsis baronii* occurs in moist montane forest and bamboo-dominated forest, at 850–1500 m altitude, usually on steep slopes, less often on ridge-crests.

Management *Dypsis baronii* is reproduced by seeds, which are available on the international market. Seeds germinate in 1–3 months.

Genetic resources and breeding *Dypsis baronii* is common and occurs over a large area in Madagascar. There is no danger of genetic erosion.

Prospects *Dypsis baronii* may remain of local importance for the production of palm heart as it is one of the more widespread *Dypsis* species. It seems to have potential for sustainable production because it grows in clumps. This elegant palm has great potential as an ornamental in parks and gardens.

Major references Dransfield, J. & Beentje, H.J., 1995; Jumelle, H., 1945.

Other references Davies, R.I. & Pritchard, H.W., 1998; Dransfield, J. & Marcus, J., 2002; Haynes, J. & McLaughlin, J., 2000; Houser, K.A., 1996; Johnson, D.V., 1996; Johnson, D.V., 1998.

Authors W.J. van der Burg

DYPSIS MANANJARENSIS (Jum. & H.Perrier) Beentje & J.Dransf.

Protologue J.Dransf. & Beentje, The palms of Madagascar: 163 (1995).

Family Arecaceae (Palmae)

Synonyms *Chrysalidocarpus mananjarensis* Jum. & H.Perrier (1913), *Chrysalidocarpus fibrosus* Jum. (1922).

Origin and geographic distribution *Dypsis mananjarensis* is endemic to Madagascar.

Uses *Dypsis mananjarensis* provides good quality palm heart, which is slightly bitter. The bark produces fibre that was formerly much used by the local population. The wood is very hard and used for making planks for houses. In a young stage the palm can be used as an ornamental for in-house decoration; older plants are attractive in gardens and parks.

Botany Palm with solitary trunk 6–25 m tall and up to 30 cm diameter; crown shaft up to 1.6 m long. Leaves 6–10 in the crown, tristichous, pinnately compound; sheath 0.6–1.6 m long, petiole up to 12 cm long, rachis 3–3.5 m long; leaflets 120–150 on each side of the rachis, irregular or in groups of 3–7, basal leaflets up to 150(–300) cm long, median leaflets up to 135 cm long. Inflorescence below the leaves, c. 150 cm long, branched to 3 orders; peduncle 18–40 cm long, arching, branches pendulous; bracts up to 120 cm long; rachis up to 100 cm long, branches up to 60 cm long, with male and female flowers. Flowers unisexual, 3-merous; male flowers with 6 stamens and a rudimentary pistil; female flowers with superior, apparently 1-celled ovary and rudimentary stamens. Fruit a globose drupe 4–6 mm in diameter, 1-seeded. Seed globose, 3.5–4.5 mm in diameter; endosperm uniform.

Dypsis comprises about 140 species, all endemic to Madagascar except 2 occurring in Comoros and 1 on Pemba Island.

Some *Dypsis* species apparently related to *Dypsis mananjarensis* have been reported as sources of palm heart: *Dypsis madagascariensis* (Becc.) Beentje & J.Dransf., *Dypsis pilulifera* (Becc.) Beentje & J.Dransf., *Dypsis prestoniana* Beentje and *Dypsis tsaravoasira* Beentje. The first species is more important for its timber, the other ones are even more rare than *Dypsis mananjarensis*.

Ecology *Dypsis mananjarensis* occurs in moist or dry forest, on slopes up to 200 m altitude.

Management *Dypsis mananjarensis* is reproduced by seeds, which are offered for sale on the international market. There are about 875 seeds per kg.

Genetic resources and breeding The conservation status of *Dypsis mananjarensis* is rated as 'vulnerable' on the IUCN red list of threatened plants. Though this species may be locally common, the total number of trees probably does not exceed a few hundred. Over the whole distribution area it is threatened by forest clearance for agricultural land or by burning; the cutting for palm heart targets this palm specifically.

Prospects Exploitation of the remaining stands of *Dypsis mananjarensis* for its palm heart should be stopped. It does not seem to have potential for sustainable production because it has a solitary trunk. There is interest from gardeners in growing this palm. However, because of its increasing rarity the collection of seeds from the wild for the purpose of international trade should be controlled.

Major references Dransfield, J. & Beentje, H.J., 1995; Jumelle, H., 1945.

Other references Davies, R.I. & Pritchard,

H.W., 1998; Dransfield, J. & Marcus, J., 2002; Haynes, J. & McLaughlin, J., 2000; Houser, K.A., 1996; IUCN, 2002; Johnson, D.V., 1996; Johnson, D.V., 1998; Walter, K.S. & Gillett, H.J., 1998.

Authors W.J. van der Burg

EDITHCOLEA GRANDIS N.E.Br.

Protologue Bull. Misc. Inform. Kew 1895: 220 (1895).

Family Asclepiadaceae (APG: Apocynaceae)

Synonyms *Edithcolea sordida* N.E.Br. (1903).

Vernacular names Persian carpet flower (En). Tapis persan (Fr).

Origin and geographic distribution *Edithcolea grandis* has been found wild in Ethiopia, Somalia, Kenya, Tanzania and Yemen. Occasionally it is cultivated in 'desert gardens'.

Uses In Ethiopia and Somalia the stems are eaten as a vegetable. *Edithcolea grandis* has potential as an ornamental succulent with beautiful flowers. The flowers have been described as: 'resembling a Tudor Rose in shape and with a colour more like a beautifully toned Persian carpet than anything else'.

Botany Succulent, perennial, leafless, decumbent herb, up to 30(–75) cm tall; stem 2–3 cm in diameter, more or less branched, glabrous, 5-angled, angles armed with hard, brown, very acute, spinelike teeth. Flowers usually solitary at the apex of the branches, bisexual, regular, 5-merous; pedicel 1.5–2 cm long; calyx divided with ovate-lanceolate lobes 8 mm × 2 mm; corolla rotate, 8–12.5 cm in diameter, tube 6–8 mm × 3–9 mm, disk with concentric dark red ridges, usually white-yellowish with dark purple-brown spots confluent at the base of each lobe in an arc, lobes ovate-acute, up to 5 cm × 2.5–3 cm, bordered with long clavate purple hairs to about the middle where the borders incurve and form a broad hairy arc across each of the lobes, usually dark purple-brown above the hairy arc; outer corona consisting of oblong, acutely bifid lobes 1 mm long, inner corona of erect fleshy lobes 2 mm long, inflexed over the anthers; ovary superior, style not exceeding the anthers, stigma 5-lobed.

A form with profusely branching stems and a rather shrubby growth, and obtuse stem-angles which are often spirally twisted, has been separated as var. *baylissiana* Lavranos & Hardy.

Ecology In the wild *Edithcolea grandis* grows in desert-like, dry and hot localities, in full sun or sometimes in the light shade of rocks or other plants, on sandy soils.

Management Propagation is possible by seed and by cuttings. Stem cuttings root easily and best results are obtained at temperatures above 27°C in light shade; the soil has to be well drained because the plant rots extremely easily. Plants tolerate temperatures as low as 4°C, but the temperature should preferably not drop below 12°C. Established plants need much sun for growth, so cultivation is difficult in many temperate regions. Cultivated plants are offered for sale in Europe for € 7.5–11.

Genetic resources and breeding In the wild, *Edithcolea grandis* is found very locally and it should be protected wherever it grows.

Prospects Although the stems of *Edithcolea grandis* are said to be edible, its commercial cultivation (possibly including tissue culture propagation) and trade as an ornamental may have more potential.

Major references Lavranos, J.J. & Hardy, D.S., 1963; Schlieben, H.J., 1963; White, A. & Sloane, B.L., 1937.

Other references Brown, N.E., 1902–1904; Westphal, E., 1975.

Authors P.C.M. Jansen

EMILIA COCCINEA (Sims) G.Don

Protologue Hortus Brit. ed. 3: 382 (1839).

Family Asteraceae (Compositae)

Chromosome number $2n = 10$

Synonyms *Cacalia coccinea* Sims (1803), *Emilia sagittata* auct. non DC.

Vernacular names Tassel flower, Cupid's paintbrush, red thistle (En). Emilie, cucolie écarlate (Fr). Kilembe cha mbwana, ulimi wa ngombe (Sw).

Origin and geographic distribution *Emilia coccinea* is native to DR Congo, Burundi, Sudan, Kenya, Uganda, Tanzania, Malawi, Zambia, Angola, Zimbabwe and Mozambique. Red- and purple-flowered plants have been imported in Mauritius and have become naturalized locally.

Uses The use of *Emilia coccinea* as a vegetable is reported from Kenya, Tanzania and Malawi. In Tanzania leaves are chopped and cooked alone or with pulses such as peas and beans. In Malawi the leaves are only occasionally eaten as a side dish; they are considered to have an unpleasant taste.

In Tanzania eye inflammations are treated by applying a cold water compress of the bruised plant or by soaking leaves mixed with those of *Ipomoea eriocarpa* R.Br. in water, after which the infusion is used for eye drops. Crushed green leaves are used to treat wounds, sores and sinusitis. Dried powdered leaves are also applied to sores. Roots or leaves are boiled and the decoction is used to treat syphilis. The roots are used to treat colic in babies in Tanzania and as a chest medicine in Kenya. *Emilia coccinea* is widely cultivated as an ornamental in tropical, subtropical and temperate regions.

Properties All data on the nutritive value published under the name *Emilia coccinea* appear to refer to *Emilia lisowskiana* C.Jeffrey from West Africa. Toxic pyrrolyzidine alkaloids and flavonoids have been isolated from other *Emilia* species. Fresh leaf juice, methanolic and aqueous extracts of *Emilia sonchifolia* (L.) DC. and *Emilia prenanthoidea* DC. have shown antimicrobial, antioxidant and anti-inflammatory activities in various studies.

Botany Erect annual herb up to 120 cm tall; stem pubescent in lower part, glabrous in upper part, or rarely glabrous throughout. Leaves alternate, simple; lower leaves shortly petiolate, blade spatulate to elliptical, up to 12 cm × 5 cm; median and higher leaves sessile, blade spatulate to lanceolate, up to 20 cm × 6 cm. Inflorescence a terminal head, 1–6 together in corymbs; involucral bracts (8–)13(–21). Flowers bisexual, regular, 5-merous; corolla tubular, 5–9.5 mm long, yellow to orange or red (sometimes scarlet-red in ornamental cultivars); stamens with cohering anthers forming a tube; ovary inferior, 1-celled, style-arms terminating in an appendage of fused papillae. Fruit an achene 2–5 mm long, shortly hairy; pappus 3–5 mm long.

Emilia comprises about 100 species and is indigenous in the Old World tropics. About 50 species are found in Africa, and several of these have become naturalized in the Americas. *Emilia* is closely related to *Senecio*. Vegetatively it resembles species of *Sonchus* but it can be distinguished by its solid stems and the absence of milky sap. *Emilia lisowskiana* and *Emilia praetermissa* Milne-Redh. have often been misidentified as *Emilia coccinea*, and uses, properties and chromosome numbers reported in the literature for *Emilia coccinea* often refer to either of these 2 related species. The ranges of *Emilia lisowskiana* and *Emilia coccinea* overlap in DR Congo, Angola and Zambia but are separated ecologically, those of *Emilia praetermissa* and *Emilia coccinea* do not overlap although both occur in DR Congo. Among gardeners the names *Emilia flammea* and *Emilia javanica* are wrongly applied to ornamental *Emilia coccinea*.

Ecology *Emilia coccinea* is a weed of roadsides, waste places and fallow land. In eastern Africa it is found in dry areas up to 2000 m altitude.

Management In Tanzania *Emilia coccinea* is collected during the rainy season for home consumption and traded in local markets. As an ornamental it can be multiplied by cuttings, but is more commonly grown from seed. It is grown at a close spacing of about 15 cm and can be used as a cut flower and for drying.

Genetic resources and breeding *Emilia coccinea* is a widespread and common weedy species which is not threatened by genetic erosion. Breeding and selection for ornamental purposes has resulted in distinct cultivars, among them 'Scarlet Magic'.

Prospects As a vegetable *Emilia coccinea* is likely to remain only locally important. In view of the local medicinal uses and interesting properties of its close relatives, pharmacological research is desirable. As an annual ornamental it has a bright future in temperate regions.

Major references Jeffrey, C., 1997; Lisowski, S., 1997; Ruffo, C.K., Birnie, A. & Tengnäs, B., 2002.

Other references Burkill, H.M., 1985; Hind, D.J.N., Jeffrey, C. & Scott, A.J., 1993; Huxley, A., 1992b; Kokwaro, J.O., 1993; Olorode, O., 1973; Watt, J.M. & Breyer-Brandwijk, M.G., 1962; Williamson, J., 1955; Yuyu Suryasari Poerba, 2003.

Authors C.H. Bosch

EMILIA LISOWSKIANA C.Jeffrey

Protologue Kew Bull. 52(1): 208 (1997).

Family Asteraceae (Compositae)

Chromosome number $2n = 10$

Synonyms *Emilia coccinea* auct. non (Sims) G.Don.

Origin and geographic distribution *Emilia lisowskiana* occurs naturally in Sierra Leone, Liberia, Côte d'Ivoire, Ghana, Togo, Nigeria, Cameroon, Equatorial Guinea, Central African Republic, DR Congo, Zambia and Angola, and is doubtfully reported for Guinea, Sudan and Uganda.

Uses In West Africa and DR Congo the

leaves are occasionally eaten as a vegetable, either fresh in salads or cooked. In Nigeria, Cameroon and Gabon the leaves are used to treat eye disorders, and also filariasis. In Gabon the macerated leaves are used to treat heart problems and crushed leaves mixed with copper filings are used to dress ulcers. In Nigeria a leaf decoction is used as a febrifuge. In Congo the leaf sap is used to treat all kinds of skin troubles (breast abcesses, ulcers caused by yaws, leprous affections), as well as against mange, lice and ringworm. Hernia, backache, syphilis, gonorrhoea, sore throat, convulsions, enlarged spleen, vertigo, epilepsy and menstrual problems are all recorded as being treated traditionally with *Emilia lisowskiana*. Laxative and anti-abortifacient properties are also attributed to *Emilia lisowskiana*. The plants serve as fodder for rabbits and guinea pigs in Gabon.

Properties The composition of fresh leaves per 100 g edible portion is: water 79.9 g, energy 268 kJ (64 kcal), protein 3.2 g, fat 0.7 g, carbohydrate 14.0 g, fibre 1.9 g, Ca 260 mg and P 52 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). Toxic pyrrolyzidine alkaloids and flavonoids have been isolated from other *Emilia* species. Fresh leaf juice, methanolic and aqueous extracts of *Emilia sonchifolia* (L.) DC. and *Emilia prenanthoidea* DC. have shown antimicrobial, antioxidant and anti-inflammatory activities.

Botany Erect annual herb up to 90 cm tall; stem glabrous to slightly pubescent. Leaves alternate, simple; lower leaves shortly petiolate, petiole winged, blade spatulate to elliptical, c. 3.5 cm × 3 cm; median and higher leaves sessile, blade ovate or sometimes lyrate, up to 9 cm × 6 cm. Inflorescence a terminal, discoid head, 2–4 together in corymbs, 12–16-flowered; involucral bracts 12–16. Flowers bisexual, regular, 5-merous; corolla tubular, 7–8(–10) mm long, orange-yellow to orange; stamens with cohering anthers forming a tube; ovary inferior, 1-celled, style-arms apically truncate. Fruit an achene 2 mm long, shortly hairy; pappus 6 mm long.

Emilia comprises about 100 species and is indigenous in the Old World tropics. About 50 species are found in Africa, and several of these have become naturalized in the Americas. *Emilia* is closely related to *Senecio*. Vegetatively it resembles species of *Sonchus* but it can be distinguished by its solid stems and the absence of milky sap. *Emilia lisowskiana* and *Emilia praetermissa* Milne-Redh. have often been misidentified as *Emilia coccinea* (Sims) G.Don, and uses, properties and chromosome numbers reported for *Emilia coccinea* often refer to either of these 2 related species. The ranges of *Emilia lisowskiana* and *Emilia coccinea* overlap in DR Congo, Angola and Zambia, but are separated ecologically. *Emilia praetermissa* occurs within the range of *Emilia lisowskiana*. *Emilia praetermissa* has similar uses as *Emilia lisowskiana*, from which it can be distinguished by the pale (white or mauve with pinkish tinge) corolla and by less (c. 10) involucral bracts. *Emilia praetermissa* appears to be tetraploid and is found in unshaded localities.

Ecology *Emilia lisowskiana* occurs in dense, usually secondary forest, forest margins and plantations (e.g. banana, oil palm) up to 1700 m altitude.

Management *Emilia lisowskiana* is considered an obnoxious weed in pineapple plantations as it is an alternative host of the nematode *Pratylenchus brachyurus*.

Genetic resources and breeding *Emilia lisowskiana* is widespread and common, and is not threatened by genetic erosion.

Prospects As a vegetable *Emilia lisowskiana* is likely to remain only locally important. In view of the local medicinal uses and interesting properties of its close relatives, pharmacological research is desirable.

Major references Busson, F., 1965; Gnonhouri Goly, P. & Téhé, H., 1997; Jeffrey, C., 1997; Lisowski, S., 1990; Lisowski, S., 1997.

Other references Burkill, H.M., 1985; Gill, L.S. & Omoigui, J.D., 1987; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Morton, J.K., 1993; Olorode, O., 1973; Raponda-Walker, A. & Sillans, R., 1961; Yuyu Suryasari Poerba, 2003.

Authors C.H. Bosch

ERUCA VESICARIA (L.) Cav.

Protologue Descr. pl.: 426 (1802).
Family Brassicaceae (Cruciferae)
Chromosome number $2n = 22$
Synonyms *Eruca sativa* Mill. (1768).

Vernacular names Garden rocket, rocket salad, rucola, arugula (En). Roquette (Fr). Eruca, rúcola (Po).

Origin and geographic distribution *Eruca vesicaria* originated in the Mediterranean region and western Asia extending as far as Afghanistan, where it is still a fairly common wild plant. Its distribution is expanding

Eruca vesicaria – planted

through escapes from cultivation and it can now be found as an occasional weed in western and central Europe, western and central Asia, North America and Australia, and also in tropical Africa (e.g. Ethiopia, Zimbabwe) and South Africa. Cultivation probably started in northern Africa and the eastern Mediterranean region and later extended into the Sahel region. A second region where the cultivation of garden rocket has a long history extends from western and central Asia to northern India. Currently, garden rocket is cultivated all around the world, but remains most important in the Mediterranean region. In Africa it is grown throughout the Sahel region, from Mauritania in the west to Ethiopia and Eritrea in the east. It is especially popular in Sudan.

Uses Garden rocket is an ancient crop revered by the ancient Greeks, who used both the seed oil and the leaves for their alleged aphrodisiac properties. It is also an ancient crop in Afghanistan, Pakistan and northern India where it is primarily grown for its oil called 'jamba oil' or 'taramira oil'. In the Mediterranean region it developed into a salad vegetable. The taste of the leaves resembles that of watercress, being similarly sharp with a mustard-like pungency. Young, fresh leaves that are not too pungent are becoming increasingly popular in western cuisine and are consumed raw in green salads. They are often added steamed or raw to Italian dishes and pizzas. In Arab countries pieces of meat served with rocket leaves form a popular dish; these leaves, locally called 'gargeer', are generally more mature and therefore sharper than the ones eaten in salads in Europe. Older leaves and seeds are used as a condiment and mature leaves can be cooked or utilized in sauces. Another vegetable use is as 'rocket sprouts', whereby the young seedlings are cut when the cotyledons are fully opened or when the first pair of true leaves is present. In Africa garden rocket is used as a vegetable, a condiment and as an oil crop.

Garden rocket is used as a medicinal plant against eye infections and to treat digestive and kidney problems. It is considered an excellent stomachic and stimulant, and is also used as a diuretic and antiscorbutic. The leaves are used as a rubefacient on the skin. Garden rocket has always been considered a potent aphrodisiac and people in the Mediterranean region still use it as such. Its oil can be used for massage and for soothing the skin. Garden rocket can cause burning reactions.

The seed oil has a high erucic acid content and is used as an industrial oil for lubrication and illumination. The seeds are also used to produce a kind of mustard. Taramira oil and jamba oil are still used in India for pickling. Its use as a salad or cooking oil is limited because of its initial acridity; the acridity disappears after storage for 6 months and the oil can then be used for cooking purposes. The leaves and crop residues are fed to camels, cattle and sheep, and the cake remaining after oil extraction is also used to feed livestock.

Production and international trade Garden rocket is popular in the Mediterranean region and Sudan, and in Sudan alone there is about 3000 ha of year-round cultivation under irrigation, mainly for the leaves. No statistics on growing areas are available for other Sahel countries. Garden rocket is traded in local markets throughout northern Africa. It is becoming increasingly important as a salad crop in western Europe and the United States, but statistics on production are not available.

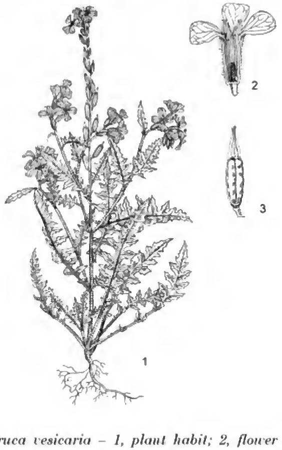
Properties The composition of fresh garden rocket leaves per 100 g edible portion is: water 91.8 g, energy 88 kJ (21 kcal), protein 2.7 g, fat 0.2 g, carbohydrate 3.7 g, fibre 0.9 g, Ca 352 mg, P 46 mg, Fe 0.8 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). The vitamin A content is 4770 IU.

The leaves contain glucosinolates, of which 4-mercaptobutyl glucosinolate is the most important; 4-methylthiobutyl glucosinolate and 4-methylsulfinylbutyl glucosinolate are present at lower concentrations. These compounds contribute to the unique odour and flavour of garden rocket. Glucosinolates are becoming increasingly important as flavour precursors,

cancer prevention agents and crop protectants. The seed oil is rich in erucic acid and gadoleic acid, containing 33–45% and 7.3–9.8%, respectively. The seeds also contain glucosinolates. Tests showed amelioration of alloxan-induced diabetes mellitus and oxidative stress in rats by daily oral administration of the seed oil.

Adulterations and substitutes As a spicy vegetable, garden rocket can be replaced by watercress (*Nasturtium officinale* R.Br.), radish (*Raphanus sativus* L.) and to a lesser extent by leaf mustard (*Brassica juncea* (L.) Czern.) and white mustard (*Sinapis alba* L.). In North Africa and Europe, it is frequently replaced by other species that are also called rocket and especially by *Diplotaxis tenuifolia* (L.) DC., which is generally milder in taste. As an oil seed or mustard crop it can be replaced by several *Brassica* species.

Description Erect annual herb up to 80(–100) cm tall, branched; stem glabrous or sparsely covered with rough hairs. Leaves alternate, petiolate (upper ones almost sessile), lyrate-pinnatifid, up to 12 cm × 4 cm, irregularly serrate. Inflorescence a terminal raceme without bracts. Flowers bisexual, regular, 4-merous; sepals free, erect, c. 1 cm long; petals free, spatulate, distinctly clawed, up to 2 cm × 1 cm, white to pale yellow or pale violet with violet veins; stamens 6, free; ovary superior, elongate, 2-celled, style simple. Fruit an ellipsoid silique up to 4 cm long, with a distinct, flat beak, longitudinally dehiscent, many-seeded. Seeds 1.5–2.5 mm long, smooth, brownish.



Eruca vesicaria – 1, plant habit; 2, flower in longitudinal section; 3, fruit.
Redrawn and adapted by Iskak Syamsudin

Other botanical information *Eruca* comprises about 5 species and is native to the Mediterranean region and western Asia. Two subspecies of *Eruca vesicaria* are distinguished: subsp. *vesicaria* with persistent sepals all pouched, and subsp. *sativa* (Mill.) Thell. with caducous sepals of which only the outer two are pouched. The latter is often considered to represent a distinct species: *Eruca sativa* Mill. The leafy vegetable belongs to subsp. *sativa*.

Growth and development Germination takes about 1 day at 25°C, 2–3 days at lower temperatures. The first harvest of rosette leaves may start 3–4 weeks after germination. Garden rocket may produce flowers as early as one month after planting and seeds can be collected soon thereafter. Types grown specifically for their leaves usually flower about three weeks later than those grown for their oil seeds.

Ecology Garden rocket grows spontaneously in disturbed localities including abandoned gardens and roadsides. It prefers a hot, dry climate and full sun. It is a hardy plant, which requires little care. Under favourable climatic conditions it can be grown on almost any type of soil, but it prefers sandy and sandy-loam soils. Garden rocket tolerates salt reasonably well.

Propagation and planting The seeds are sown on raised beds in shallow furrows spaced at 15–22 cm or seeds are broadcast directly in the field. A density of 100 plants/m^2 was found to give the highest yield, but in Italy densities of up to 300 plants/m^2 are used. The seed requirement is about 20 kg/ha for row planting and 50–80 kg/ha when broadcast. For oil production, wider spacings and correspondingly lower seed rates are used. In the subtropics sowing takes place in late winter or early spring, during cool but mild weather in moist, fertile soil. To encourage emergence, the seed is covered with 1–3 cm of light, sieved soil.

Management Although garden rocket is fairly tolerant of salt, the high salt level often found in the top layers of desert soils has a negative impact on germination and further growth. Some farmers therefore first irrigate

their land to leach out excessive salts from the top soil. Subsequently irrigation should be applied regularly at short intervals of 3–4 days. Once established, garden rocket requires little irrigation. Because of the fast early growth only light weeding is needed. It is recommended that organic manure be used at a rate of 25–50 t/ha during land preparation and that urea be added at a rate of 100 kg/ha 3 weeks after planting. Nitrogen fertilizing and shading result in more tender leaves with a milder taste. Fertilizer recommendations for garden rocket grown as an oil crop are lower.

Diseases and pests Garden rocket is very susceptible to club root (*Plasmodiophora brassicae*). Powdery mildew (*Erysiphe cichoracearum*) is one of the few other diseases that affect garden rocket. Flea beetles (*Phyllotreta cruciferae*) often gnaw small holes in the foliage and it is therefore important to observe a proper crop rotation. Other pests affecting garden rocket are thrips (*Caliothrips* spp.) and jassids (*Empoasca lybica*).

Harvesting Harvesting starts 3–6 weeks after sowing, when young, tender leaves and shoots are picked. The bottom set of leaves should be left to allow new shoots to regenerate. If cut too low the plant is killed. A total of 2–3 cuts are usually made before the plant starts flowering and no further leaf harvests are possible. Farmers usually leave their plants in the field to produce seed for the next season's crop.

Yield A good yield of leaves is 12–16 t/ha, most of which is collected from the first harvest. In India seed yields range from 350–1000 kg/ha.

Handling after harvest Leaves can be stored in plastic boxes for 2–3 days at 0°C.

Genetic resources Many landraces exist, allowing ample scope for selection. The largest collections of *Eruca* germplasm are maintained at the Institute of Germplasm in Bari, Italy, at NBPGR, New Delhi and Haryana Agricultural University in India, and at the N.I. Vavilov All-Russian Scientific Research Institute of Plant Industry in Petersburg, Russia. In 1985, 25 samples of germplasm of *Eruca vesicaria* were collected in north-eastern Sudan.

Breeding A wide variability has been observed with regard to erucic acid and glucosinolate contents. However, the development of cultivars with a low glucosinolate content does not appear to be an improvement objective since it would diminish the characteristic flavour. Attempts have been made to use *Eruca vesicaria* as a genetic resource for improving other crucifers. In this way, intergeneric hybrids have been obtained with *Raphanus sativus* L., *Brassica rapa* L. and *Brassica oleracea* L. Somatic hybrids have been obtained through the fusion of protoplasts with *Brassica napus* L. and *Brassica juncea* (L.) Czern. There are types of garden rocket which are resistant to mustard aphid and can tolerate several sorts of stress conditions as well as *Fusarium oxysporum*.

Prospects Garden rocket is a nutritious vegetable and although not everybody appreciates its characteristic pungent flavour, more attention should be given to its production and improvement. Sufficient genetic variation exists to be able to modify its taste. It also deserves further testing as an oil seed crop for Sahel countries and other drought-prone regions since it tolerates low rainfall conditions.

Major references Andrews, F.W., 1950; Broun, A.F. & Massey, R.E., 1929; Burkill, H.M., 1994; Jonsell, B., 2000; Nuez, F. & Hernández Bermejo, J.E., 1994; Padulosi, S. & Pignone, D., 1996; Schippers, R.R., 2002a; Yaniv, Z., Schafferman, D. & Amar, Z., 1998.

Other references Bennett, R.N. et al., 2002; Burgstaller, H., Mamoun Beshir Mohamed & Mahmoud S. Hassan, 1984; Edwards, S.B., 1991; El Missiry, M.A. & El Gindy, A.M., 2000; Exell, A.W., 1960; Jansen, P.C.M., 1999; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Marais, W., 1970; Rich, C.G., 1991; Zeven, A.C. & Zhukovsky, P.M., 1975.

Sources of illustration Gómez-Campo, C., 1993; Coste, H., 1901.

Authors H.S. Ibn Oaf

ERUCASTRUM ARABICUM Fisch. & C.A.Mey.

Protologue Index sem. hort. petrop. 5: 35 (1839).

Family Brassicaceae (Cruciferae)

Chromosome number $2n$ = 14, 16, 30, 32

Synonyms *Brassica schimperi* Boiss. (1842).

Vernacular names Ethiopian kale (En).

Origin and geographic distribution *Erucastrum arabicum* possibly originates from montane eastern Africa, but is now found from Sudan to Arabia, throughout eastern and central Africa, to Botswana and Namibia. It is also an introduced weed in many other regions of the world.

Uses *Erucastrum arabicum* is a leafy vegetable collected from the wild. Its above-ground

parts are chopped and boiled in salty water for about one hour, and eaten as a vegetable in sauce or soup. The young leaves can also be eaten raw as salad. In some areas it is considered a typical famine food, in other areas as a normal wild vegetable. It is also grazed by domestic stock. In Ethiopia the seed is occasionally sold on local markets with the same vernacular name as *Brassica carinata* A.Br. ('meshisha'), which is a highly appreciated vegetable and which has a useful seed oil for burning, cooking (after refining) and traditional medicine. This suggests that *Erucastrum arabicum* seeds are occasionally used for the same purposes.

Properties In Ethiopia it is believed by some that eating *Erucastrum arabicum* can have side effects such as drowsiness and drying of the skin. The seed contains about 35% oil with as major fatty acids erucic acid, linoleic acid and linolenic acid.

Botany Annual herb up to 1 m tall, branched or unbranched, sparsely hispid on stem and leaves. Leaves alternate, simple, lower leaves largest and with short petiole, upper leaves sessile, smaller and less divided; blade spatulate to lyrate-pinnatifid, up to 18 cm × 5 cm, terminal lobe large and rounded, lateral lobes up to 4 pairs and triangular to oblong, margins irregularly dentate, sinuate or slightly uneven. Inflorescence a terminal, dense raceme, in fruit lax and up to 40 cm long. Flowers bisexual, regular, 4-merous; pedicel slender, ascending, up to 2 cm long; sepals oblong, c. 3 mm long; petals spatulate to almost clawed with oblong blade, 3.5–6 mm × 2 mm, yellow; stamens 6, 4 longer ones c. 5 mm long; ovary superior, cylindrical, 2-celled, style short, stigma semiglobose. Fruit a straight silique 1.5–5 cm × 1.5 mm, with up to 4.5 mm long beak, dehiscent with 2 valves. Seeds ellipsoid, c. 1 mm long, brown, smooth to finely reticulate.

Erucastrum comprises about 20 species and is distributed in Africa, Arabia and Europe. In Africa 5 species occur. *Erucastrum arabicum* is often confused with some *Brassica carinata* types, which however, have wider fruits.

Ecology *Erucastrum arabicum* grows in disturbed localities in upland forest and as a weed in cultivated land, from sea-level up to 2500 m altitude, but it is most common at 1500–2000 m.

Genetic resources and breeding *Erucastrum arabicum* is widespread and not in danger of genetic erosion. Several *Brassica* genebanks have a few accessions of *Erucastrum arabicum*. Because it spread widely as a weed it is now the most common crucifer in eastern Africa. Its variability is largely explained by different growing conditions.

Prospects *Erucastrum arabicum* will remain of importance locally as a wild vegetable, certainly in times of food scarcity. Its nutritional composition and chemical properties need research.

Major references Jonsell, B., 1982b; Maundu, P.M., Ngugi, G.W. & Kabuye, C.H.S., 1999; Robyns, W. & Boutique, R., 1951; Seegeler, C.J.P., 1983; Westphal, E., 1975.

Other references Chweya, J.A., 1985; Exell, A.W., 1960; Jonsell, B., 2000; Katende, A.B., Ssegawa, P. & Birnie, A., 1999; Marais, W., 1970; Schippers, R.R., 2000.

Authors P.C.M. Jansen

ERYTHROCOCCA KIRKII (Müll.Arg.) Prain

Protologue Ann. Bot. 25: 609 (1911).

Family Euphorbiaceae

Synonyms *Claoxylon kirkii* Müll.Arg. (1864), *Erythrococca mitis* Pax (1895).

Origin and geographic distribution *Erythrococca kirkii* is found in Kenya, Tanzania and Mozambique.

Uses In Tanzania and occasionally in Kenya chopped leaves of *Erythrococca kirkii* are eaten cooked as a vegetable, alone or in a mixture with pounded groundnuts, coconut milk or other vegetables, and served with a staple food. Ripe fruits are eaten raw. The leaves are also used for fodder and the wood for firewood. Occasionally, the plant is cultivated as an ornamental.

Properties The composition of *Erythrococca kirkii* leaves is not known. Fresh leaves of *Erythrococca bongensis* Pax (from Central and East Africa) contain per 100 g: water 68 g, protein 7.2 g, fat 2.7 g, carbohydrate 18.5 g, fibre 4.3 g, Ca 678 mg and P 107 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968).

Botany Dioecious, much-branched, straggling or erect shrub up to 4.5 m tall, with rough bark. Leaves alternate, simple; stipules broadly triangular; petiole 0.5–2.5 cm long, purplish; blade ovate to elliptical, 5–15 cm × 2–8 cm, base cuneate, apex acuminate, margin crenate, almost glabrous, green, purplish tinged when young. Inflorescence a subsessile glomerule 1–2 cm long, female ones fewer flowered than male ones. Flowers unisexual, regular, small, petals absent; male flowers with pedicel c. 1 cm long, 3 triangular, green-white

calyx lobes c. 1 mm long, an annular disk and usually 8 stamens; female flowers with pedicel 3–4 mm long, calyx lobes smaller than in male, yellow, 3 scale-like disk glands and 3-lobed superior ovary crowned by 3 free styles. Fruit a 3-lobed capsule, breaking into 3 globular, 1-seeded parts 3–4 mm in diameter each. Seeds subglobose, 3 mm in diameter, with yellow, orange or red aril.

Erythrococca comprises about 50 species and is confined to Africa. The leaves of some other species are also occasionally used as a vegetable: *Erythrococca africana* (Baill.) Prain in Benin, *Erythrococca atrovirens* (Pax) Prain in DR Congo, *Erythrococca chevalieri* (Beille) Prain and *Erythrococca welwitschiana* (Müll.Arg.) Pax & K.Hoffm. in Congo, and *Erythrococca menyharthii* (Pax) Prain in southern Africa. They are not treated separately in PROTA.

Ecology *Erythrococca kirkii* grows in forest edges and coastal bushland or thicket, inland mostly along rivers and lakesides, up to 1250 m altitude.

Management In Tanzania the leaves are collected from the wild in February–June and sold fresh on local markets. They are not stored. *Erythrococca kirkii* is not cultivated or protected, but it can be propagated by seed.

Genetic resources and breeding *Erythrococca kirkii* is widespread and locally common, and not in danger of genetic erosion.

Prospects *Erythrococca kirkii* is a wild vegetable in parts of East Africa which merits more attention because it has harvestable leaves for considerable periods of the year. Its nutritional value requires investigation.

Major references Radcliffe-Smith, A., 1987; Radcliffe-Smith, A., 1996; Ruffo, C.K., Birnie, A. & Tengnäs, B., 2002.

Other references Beentje, H.J., 1994b; Govaerts, R., Frodin, D.G. & Radcliffe-Smith, A., 2000; Leung, W.-T.W., Busson, F. & Jardin, C., 1968.

Authors P.C.M. Jansen

GALINSOGA PARVIFLORA Cav.

Protologue Icon. 3(2): 41 (1796).
Family Asteraceae (Compositae)
Chromosome number $2n = 16$

Vernacular names Gallant soldier, chickweed, smallflower galinsoga, quickweed (En). Galinsoga à petites fleurs, piquant blanc (Fr). Erva da moda, picão branco (Po). Msekeseke (Sw).

Origin and geographic distribution *Galinsoga parviflora* originates from Central America. It has been introduced elsewhere and it can be found in both temperate and tropical regions. In tropical Africa it is widespread and has been collected in Cape Verde, central, eastern and southern Africa, and the Indian Ocean islands.

Uses People in Uganda, Tanzania, Malawi, Zambia, Zimbabwe and possibly elsewhere in Africa collect gallant soldier when weeding their crops. The young stems and leaves are cooked and eaten as a vegetable but flowerheads and buds are usually removed. Gallant soldier is also eaten as a vegetable in South-East Asia. In South America the dried leaves ('guascas') are an essential flavouring for certain dishes.

Gallant soldier is used for the treatment of nettle stings and similar skin inflammation by rubbing the affected skin with the leaves. The leaves are used for wound dressing in Ethiopia. The plant is grazed by livestock and used as a feed for chicken, rabbits and pigs.

Properties The leaves of gallant soldier contain per 100 g edible portion: water 88.4 g, energy 653 kJ (156 kcal), protein 3.2 g, fat 0.4 g, carbohydrate 5.2 g, fibre 1.1 g, Ca 284 mg, Mg 60 mg, P 58 mg, Fe 5.3 mg, Zn 1.3 mg, carotene 4 mg, thiamin 0.08 mg, riboflavin 0.21 mg, niacin 1.21 mg, ascorbic acid 6.7 mg (Wehmeijer, A.S. & Rose, E.F., 1983).

Tests of the plant for antibacterial and insecticidal activities have given negative results, but it had strong cardiovascular effects.

Botany Annual plant with erect to ascending stems, 20–60(–120) cm tall, glabrous or sparsely pubescent. Leaves opposite, simple; petiole 2–15 mm long; blade ovate or ovate-oblong, 1–6.5 cm × 0.5–4.5 cm, margin shallowly serrate. Inflorescence a terminal or axillary head, often in pairs; involucral bracts in 2 rows, glabrous, pales present, trifid. Ray flowers female, usually 5, white, with short ligule and marked tube; disk flowers tubular, yellow. Fruit an achene 1–2 mm long, central achenes ovate, black, with pappus consisting of white, fimbriate scales as long as the fruit, marginal achenes without pappus.

Galinsoga comprises 14 species and is indigenous in tropical America. *Galinsoga parviflora* and the tetraploid *Galinsoga quadriradiata* Ruiz & Pav. (synonyms: *Galinsoga ciliata* (Raf.) S.F.Blake, *Galinsoga urticifolia* (Raf.) S.F.Blake) have become common weeds in Africa. The latter species is more hairy.

As a weed, gallant soldier is difficult to eradicate because plants left on the ground after weeding may re-establish roots, whereas undeveloped seeds will continue to ripen even under dry conditions. Fields can soon be covered by gallant soldier because a single plant of 8–9 weeks old can produce over 7000 viable seeds and several generations are possible in each growing season. The small, lightweight fruits can be spread by the wind and the stiff pappus hairs cling to people's clothing or the fur of animals.

Ecology In tropical Africa gallant soldier is found from sea-level to 2400 m altitude. It requires medium to high rainfall conditions. Seed requires temperatures of 10–35°C and light to germinate. Buried seeds do not germinate at all, and shade also prevents germination, which is why gallant soldier is only found on open land or as a weed between young and small crop plants. It grows well in a variety of soils but prefers soil with ample nutrients and good drainage.

Management Farmers consider *Galinsoga parviflora* an indicator of high soil fertility. In Africa it is only collected from the wild and trade is limited to local markets.
Gallant soldier is a common and locally serious weed reported in wheat and maize in Ethiopia, cotton in Uganda, coffee, maize, sorghum and beans in Tanzania, wheat in Angola, vegetables in Zambia, maize in Zimbabwe and potatoes in Mozambique. It serves as an alternate host for many insects and viruses which affect crop species such as tobacco, potato and cabbage. It is also a host plant for *Phytophthora infestans* and root-knot nematodes.

Genetic resources and breeding Being a widespread weed, *Galinsoga parviflora* is not liable to genetic erosion.

Prospects Interest in *Galinsoga parviflora* is mainly directed at its control as a notorious weed. Locally, however, it will continue to make a contribution to the diet of many.

Major references Andersen, R.N., 1968; Burkill, H.M., 1985; Canne, J.M., 1977; Katende, A.B., Ssegawa, P. & Birnie, A., 1999; Wehmeyer, A.S. & Rose, E.F., 1983.

Other references Holm, L.G. et al., 1977; Kokwaro, J.O., 1993; Tredgold, M.H., 1986; van den Bergh, M.H., 1993.

Authors R.R. Schippers

GISEKIA PHARNACEOIDES L.

Protologue Mant. pl. 2: 562 (1771).
Family Aizoaceae
Chromosome number $2n = 36, 72, 108$
Synonyms *Gisekia linearifolia* Schumach. & Thonn. (1827), *Gisekia congesta* Moq. (1849), *Gisekia rubella* Hochst. ex Moq. (1849).
Vernacular names Oldmaid, gisekia (En).

Origin and geographic distribution Most probably *Gisekia pharnaceoides* originated in tropical Africa and adjacent tropical Arabia. Later it spread to southern Africa and Asia, and was introduced into the New World. In tropical Africa it is widespread in drier areas.

Uses *Gisekia pharnaceoides* is occasionally eaten as a vegetable, e.g. in Somalia, Kenya and Tanzania. It is eaten as an emergency food in West Africa and India. In DR Congo and northern Chad it is eaten as a condiment.
Young plants are eaten by domestic stock, although they may cause diarrhoea; older plants are not recommended as fodder because the fruits are said to be poisonous. There are many medicinal uses. In East Africa the whole plant is eaten as a general strength restorative, e.g. after miscarriage. In northern Africa *Gisekia pharnaceoides* is considered a purgative, in Kenya, Tanzania, southern Africa and Madagascar it is taken to cure diarrhoea. In India, Indonesia, South Africa and Madagascar it is used as a taenicide, but the plant should be consumed with great caution. In West Africa leaves are rubbed on swellings and in Tanzania the stem, pounded in butter, is placed on aching muscles. In India plant sap is used against warts. In Tanzania cooked green leaves are eaten to treat asthma, in Kenya the roots are made into a chest medicine. The seeds probably possess anthelmintic properties.

Properties In the vegetative parts of *Gisekia pharnaceoides* several phenolic acids have been identified: p-OH-benzoic acid, caffeic acid, p-coumaric acid and vanillic acid. Ferulic and sinapic acids were absent, although these are usually present in *Aizoaceae*. In the seed the tannin-like principles α- and β-gisekia have been found. Tannins are present in the whole plant.

Botany Slightly succulent, glabrous herb, green, often pinkish tinged; stem trailing, decumbent or prostrate, up to 80 cm long, sometimes longer. Leaves usually opposite, simple, subsessile; blade variable, from linear to linear-oblanceolate, oblanceolate-spatulate or elliptical, 0.5–6 cm × 0.1–2 cm, base attenuate,

apex rounded to subacute, often obscurely apiculate, entire, surface closely streaked with numerous linear, short, whitish raphides. Inflorescence an umbelliform cyme, 3–40-flowered; peduncle up to 5.5 cm long. Flowers bisexual, regular, 5-merous, greenish-white, often tinged pinkish, mauve or yellowish; pedicel fairly stout, curved, 2–8 mm long; tepals free, in fruit 1.5–3 mm long; stamens with filaments broadened at base; carpels 5, free. Fruit consisting of 5 achenes. Seeds black, smooth, minutely pitted.
The status, affinities and systematic position of *Gisekia* is still a matter of dispute. It has been variously assigned to different families: *Aizoaceae*, *Molluginaceae* and *Phytolaccaceae*. It has been suggested that *Gisekia* constitutes a separate family, *Gisekiaceae*, and can be considered as a possible connecting link between betalain-containing *Aizoaceae* and *Phytolaccaceae* and anthocyanin-containing *Molluginaceae*. The variability of *Gisekia pharnaceoides* is considerable and has resulted in numerous names of species and varieties. Best known is var. *pseudopaniculata* C.Jeffrey (plants erect or ascending, flowers in diffuse terminal cymes, pedicel threadlike, erect, 1–1.5 cm long in fruit), which is now considered a separate species: *Gisekia diffusa* M.Gilbert. Specimens with prominently crested or winged fruits are classified in var. *alata* M.Gilbert.

Ecology *Gisekia pharnaceoides* is a weed found along roadsides, in grassland, bushland and woodland, mostly on sandy soils, from sea-level up to 1700 m altitude.

Genetic resources and breeding *Gisekia pharnaceoides* is common and widespread in many tropical and subtropical parts of the world and is not in danger of genetic erosion.

Prospects The phytochemistry of *Gisekia pharnaceoides* should be better investigated in order to determine the nutritional and medicinal values. Unless such studies indicate otherwise, its use as a vegetable should not be recommended because it contains poisonous compounds.

Major references Adamson, R.S., 1961; Gilbert, M.G., 1993a; Godfrey, R.K., 1961; Jeffrey, C., 1961; Narayana, P.S. & Narayana, L.L., 1988.

Other references Burkill, H.M., 1985; Burkill, H.M., 2000; Gonçalves, M.L., 1978a; Keay, R.W.J., 1954d.

Authors P.C.M. Jansen

GNETUM AFRICANUM Welw.

Protologue Trans. Linn. Soc. 27: 73 (1869).
Family Gnetaceae
Synonyms *Thoa africana* (Welw.) Doweld (2000).
Vernacular names Eru (En). Koko (Fr). Nkoko (Po).

Origin and geographic distribution *Gnetum africanum* occurs naturally in the humid forest zones from Nigeria to the Central African Republic and to Angola.

Uses Fresh leaves of *Gnetum africanum* and the very similar *Gnetum buchholzianum* Engl., both called eru (koko in French), are widely used as a vegetable. They are usually cooked with meat or fish and occasionally consumed as a salad. Leaves are shredded into thin strips and are often eaten as part of a mixture in, for example, a groundnut-based stew. To soften this rather tough vegetable, people often mix it with waterleaf (*Talinum triangulare* (Jacq.) Willd.). Shredded leaves can be dried and preserved for later use. The seeds are eaten in Cameroon and DR Congo.
In Nigeria, eru is used for treatment of piles and high blood pressure and also as medicine against enlarged spleen, sore throat and as a purgative. In the Central African Republic the leaves are eaten to treat nausea and as an antidote to arrow poison made from *Periploca nigrescens* Afzel. In Cameroon the leaves are chewed to mitigate the effects of drunkenness and they are taken as an enema against constipation and to ease childbirth. They are also used to treat boils and fungal infections on the fingers. The supple stem is sometimes used as rope.

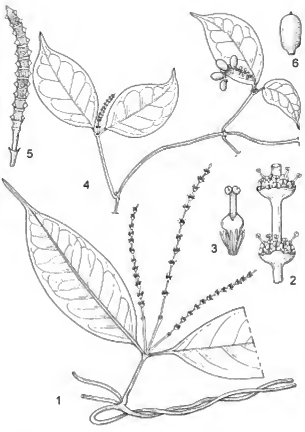
Gnetum africanum – wild

Production and international trade In trade, consignments of *Gnetum africanum* and *Gnetum buchholzianum* are often mixed. Traders will pay more for the thick dark green leaves of the latter, but much variation is also caused by growing conditions. Most eru is consumed locally, but intensive trade has developed from Cameroon and more recently also from Gabon and the Central African Republic to meet the large demand in Nigeria. Most eru from Cameroon, Gabon and the Central African Republic is transported to Idenau, a coastal village in Cameroon, and from there by boat to Nigeria. Estimates for the annual export of eru leaves (both species) to Nigeria range between 2500 t and 4000 t. Another major marketing centre is the Koilo Region in Congo. Other marketing centres in Cameroon are Campo near Kribi for export to Gabon and the Mfoundi market in Yaoundé. Dried shredded leaves are exported, mainly from Nigeria to the United States and to a lesser extent from other countries to France and the United Kingdom.

Properties The composition of *Gnetum africanum* leaves is probably comparable to *Gnetum africanum*. The dry matter content of fresh leaves is much higher than for other dark or medium green leaf vegetables. This gives a feeling of firmness during preparation, hence certain consumers consider eru as a substitute for meat. The leaves of *Gnetum africanum* are somewhat thinner and paler than the dark green leaves of *Gnetum buchholzianum*. Consequently, the content of micronutrients in the latter might be somewhat higher. Eru leaves contain C-glycosylflavones, including 2"-xylosylisoswertisin and 2"-glucosylisoswertisin, compounds that are only known from these two species; characteristic of *Gnetum africanum* is the presence of 2"-O-rhamnoylisoswertisin and apigenin-7-hesperidoside and the absence of vitexin and 2"-O-glycosylvitexin.

Adulterations and substitutes The leaves of *Gnetum africanum* can be replaced by those of the other eru species, *Gnetum buchholzianum*, or leaves of the shrub *Lasianthera africana* P.Beauv., which impart a similar taste to the dish.

Description Dioecious liana up to 10 m long but sometimes longer; branches somewhat thickened at the nodes, glabrous. Leaves decussately opposite, sometimes in whorls of 3, simple; stipules absent; petiole up to 1 cm long, canaliculate above; blade ovate-oblong to elliptical-oblong, rarely lanceolate, 5–14 cm × 2–5 cm, base attenuate, apex abruptly acuminate, obtuse or minutely apiculate, entire, thick-papery, glabrous, pale green above, paler beneath, with 3–6 pairs of strongly curved lateral veins looped near the margin. Inflorescence an unbranched catkin, axillary or terminal on a short branch, solitary but male inflorescences at apex of branches often in groups of 3, up to 8 cm long, jointed, peduncle 1–1.5 cm long, with a pair of scale-like, triangular bracts; male inflorescence with slender internodes and whorls of flowers at nodes; female inflorescence with slightly turbinate internodes and 2–3 flowers at each node. Flowers small, c. 2 mm long, with moniliform hairs at base and an envelope; male flowers with a tubular envelope and exserted staminal column bearing 2 anthers; female flowers with cupular envelope and naked, sessile ovule. Seed resembling a drupe, ellipsoid, 10–15 mm × 4–8 mm, apiculate, enclosed in the fleshy envelope, orange-red when ripe, with copious endosperm.



Gnetum africanum – 1, branch with male inflorescences; 2, part of male inflorescence; 3, male flower; 4, branch with female inflorescence and infructescence; 5, female inflorescence; 6, seed. Redrawn and adapted by W. Wessel-Brand

Other botanical information *Gnetum* com-

prises approximately 35 species of small trees, shrubs or most often lianas, found in tropical South and Central America (about 7 species), Africa (2 species) and Asia (about 25 species). They look much like dicotyledonous flowering plants (having opposite leaves with a net venation and cherry-like seeds), although in fact they are gymnosperms. The 2 African species, which are very similar, have been classified in section *Gnetum*, subsection *Micrognemones*. *Gnetum africanum* has leaves which are relatively thin and pale green. Its male catkins have slender internodes of equal width from the base to the tip. *Gnetum buchholzianum* has thick dark green leaves. The male catkins have thick internodes widening towards the terminal part.

It was recently proposed that all *Gnetum* species be transferred to *Thoa*, except two Asiatic species, mainly based on seedcoat structure.

Growth and development Both African *Gnetum* species are lianas with two different types of stems. The orthotropic ones have small, scale-like leaves and rapidly grow vertically, reaching the main branches of a tree where they produce plagiotropic stems with fully developed leaves. The orthotropic stem continues climbing until it reaches the canopy where it branches into several leafy stems. Female plants often show more vigorous growth with stronger stems than male plants. This is more obvious in *Gnetum africanum* than in *Gnetum buchholzianum*.

Eru continues to grow during the dry season and new shoots may develop where the stem has been cut or where side shoots have been removed. New shoots are also formed from rhizomes that spread along the forest floor. The distinctly coloured drupe-like seeds are probably dispersed by birds and other animals.

Ecology Eru can be found in rainforest from sea-level up to 1200 m altitude, and prefers an annual rainfall of about 3000 mm. It is usually found with other climbers on middle- and under-storey trees, frequently forming thickets. It can also be found in riverine forest in areas that are otherwise too dry for the species. *Gnetum africanum* is mostly found at the periphery of primary forest and in secondary forest. Today, it is more common than *Gnetum buchholzianum*, which is mainly found in primary forest, especially near openings created by fallen trees.

Propagation and planting Experimental plantings for domestication are being made with both species. Nurseries are now concentrating their efforts on *Gnetum buchholzianum* because it is preferred by traders and is more vigorous. Moreover, male vines of *Gnetum africanum* are less appreciated because of their smaller, thinner and paler leaves, and because of their less vigorous growth. For *Gnetum buchholzianum* there is no need to harvest only female plants. However, the field trials might show that *Gnetum buchholzianum* is more difficult to cultivate than *Gnetum africanum* because the former probably requires more shade than the latter. In experiments in Cameroon, propagation by seed was difficult because the seed is reluctant, germination taking one year or more. It is assumed that seeds need pretreatment, such as passing through the intestines of a bird, fruit bat, squirrel or other animal, before they germinate. Seed is normally found only in the tree canopy. Seed collection is thus far from easy, a further reason why eru is hardly cultivated.

Methods of vegetative propagation using leafy stem cuttings have recently been developed. It is recommended that leaf blades of cuttings be trimmed in half. Nursery beds under shade and made of well-decomposed sawdust or fine river sand can be used for propagation. Ectomycorrhizae assist the roots in absorption of nutrients; the most common species reported is *Scleroderma sinnamarense*. After about 6 weeks the rooted cuttings are transferred to polythene sleeves, bamboo pots or other containers where they remain for a further 2–3 months. The soil mixture for these containers consists of 25% sand and some compost, supplemented with forest soil. Field planting, preferably next to a young tree or shrub, takes place at the beginning of the rainy season.

Management Eru is still mainly collected from wild stands, but farmers often retain it when clearing fields. If cultivated, farmers need to provide support, e.g. by using commercial plantations of rubber trees, oil palm and other tree crops. Fences were only found to be successful when there is enough shade, and they are generally too expensive. Fully exposed plants do not grow well; their leaves are thin and pale green, and traders reject them. In experiments, nutrients, especially nitrogen, have shown a positive effect on growth and rate of leaf development.

Diseases and pests Mealy bugs are the main pest in the nursery. When eru is grown along dead poles attacked by termites, these insects will damage adjacent leaves. Diseases have not been found to reduce productivity of

eru.

Harvesting The current method of harvesting, especially for export trade, is to pull the stems or branches from trees. This leads to large-scale destruction of natural stands. Occasionally, trees have to be cut to reach leafy stems in the canopy. This is mainly done during the dry season when the forest is more accessible and when there is little work on the farm. Controlled harvesting, in which only side shoots or parts of stems are collected, is clearly better than destructive harvesting. After controlled harvesting, new shoots may develop where a stem has been cut or where side shoots have been removed. Preliminary observations indicate that 3–4 harvests per year are possible, still allowing for substantial regrowth. More frequent harvesting will result in thin leaves that are considered inferior. The first harvest may take place 6–9 months after planting. The total lifespan of eru is estimated at over 10 years.

Yield Preliminary observation indicates that in cultivation during the first harvest year the fresh leaf yield may reach 20 t/ha. This may double in subsequent years.

Handling after harvest Leafy stems remain fresh for at least a week. Stems collected from the forest are brought to collecting points from where they are either sold in the local market or exported. For this trade, whole leafy stems are packed in large bales. Selection takes place for size and texture of the leaves, and is mainly determined by species. *Gnetum buchholzianum* is more popular with consumers and more expensive because its leaves are generally thicker than those of *Gnetum africanum*. Leaves are shredded before consumption or prior to drying.

Genetic resources Eru is hardly cultivated at all at present, but there is massive exploitation of the remaining natural stands, which have almost disappeared in Nigeria and are becoming scarce in Cameroon, Gabon and the Central African Republic. There is an urgent need to collect and preserve the diversity found within the two African *Gnetum* species, preferably throughout their natural range. Accessions need to be evaluated for their agronomic potential and for their ability to germinate without the need for interventions. A small collection is currently held at the Limbe Botanic Garden, Limbe, Cameroon.

Prospects Alternatives to destructive harvesting of eru should be found. Once the new methods of propagation and cultivation have been adopted, there will be scope for development of eru as a new crop, for which there is already a high demand and for which an attractive price could be paid. Diversity found between accessions is considerable, offering scope for improvement of both quality and productivity. Research work is currently being done at Limbe Botanic Garden, Limbe, Cameroon.

Major references Fondoun, J.M. & Tiki Manga, T., 2000; Ingleby, K., 1999; Keay, R.W.J., 1954b; Mialoundama, F., 1993; Mialoundama, F. & Mbou, R., 1992; Schippers, R.R., 2000; Schippers, R.R. & Fereday, F., 1998; Shiembo, P.N., 1997; Shiembo, P.N., 1999; Shiembo, P.N., Newton, A.C. & Leakey, R.R.B., 1996.

Other references Asaha, S. et al., 2000; Bahuchet, S., 1990; Burkill, H.M., 1994; Busson, F., 1965; Carlquist, S. & Robinson, A.A., 1995; Doweld, A.B., 2000; Friedman, W.E. & Carmichael, J.S., 1998; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Lowe, J., 1984; Markgraf, F., 1930; Mialoundama, F. & Poulet, P., 1986; Okafor, J.C., 1997; Ouabonzi, A., Bouillant, M.L. & Chopin, J., 1983; Robyns, W., 1948; Stevels, J.M.C., 1990.

Sources of illustration Engler, A., 1908; Robyns, W., 1948a.

Authors R.R. Schippers & M.T. Besong

GNETUM BUCHHOLZIANUM Engl.

Protologue Bot. Jahrb. 40: 519 (1908).

Family Gnetaceae

Synonyms *Thoa buchholziana* (Engl.) Doweld (2000).

Vernacular names Eru (En). Koko (Fr). Nkoko (Po).

Origin and geographic distribution *Gnetum buchholzianum* is restricted to the humid forest zone of Cameroon.

Uses Fresh leaves of *Gnetum buchholzianum* and the very similar *Gnetum africanum* Welw., both called eru (koko in French), are widely used as a vegetable. They are usually cooked with meat or fish and occasionally consumed as a salad. Leaves are shredded into thin strips and are often eaten as part of a mixture in, for example, a groundnut-based stew. To soften this rather tough vegetable, people often mix it with waterleaf (*Talinum triangulare* (Jacq.) Willd.). Shredded leaves can be dried and preserved for later use. The seeds are also eaten.

Gnetum buchholzianum – wild

The leaves are chewed to mitigate the effects of drunkenness and they are taken as an enema against constipation and to ease childbirth. They are also used to treat boils and fungal infections on the fingers. The supple stem is sometimes used as rope.

Production and international trade In trade, consignments of *Gnetum buchholzianum* and *Gnetum africanum* are often mixed. Traders will pay more for the thick dark green leaves of the former, but much variation is also caused by growing conditions. Most eru is consumed locally, but intensive trade has developed from Cameroon to meet the large demand in Nigeria. Most eru from Cameroon is transported to Idenau, a coastal village in Cameroon, and from there by boat to Nigeria. Estimates for the annual export of eru leaves (both species) to Nigeria range between 2500 t and 4000 t. Other marketing centres in Cameroon are Campo near Kribi for export to Gabon and the Mfoundi market in Yaoundé. Dried shredded leaves are exported, mainly from Nigeria to the United States and to a lesser extent from other countries to France and the United Kingdom.

Properties The composition of *Gnetum buchholzianum* leaves per 100 g of fresh edible portion is: water 70 g (65.0–84.0), energy 432 kJ (103 kcal), protein 6.0 g (3.6–6.7), fat 1.3 g, carbohydrate 21.6 g, fibre 5.5 g, Ca 130 mg, P 54 mg, Fe 5.6 mg, ascorbic acid 100 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). The dry matter content of fresh leaves is higher than for most other dark or medium green leaf vegetables. This gives a feeling of firmness during preparation, hence certain consumers consider eru as a substitute for meat. The leaves of *Gnetum buchholzianum* are somewhat thicker and darker green than the thinner and paler leaves of *Gnetum africanum*. Consequently, the content of micronutrients in the latter might be lower. Eru leaves contain C-glycosylflavones, including 2"-xylosylisoswertisin and 2"-glucosylisoswertisin, compounds that are only known from these two species.

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Description Dioecious liana up to 10 m long but sometimes longer; branches somewhat thickened at the nodes, glabrous. Leaves decussately opposite, sometimes in whorls of 3, simple; stipules absent; petiole c. 1 cm long, canaliculate above; blade ovate-elliptical to broadly elliptical, 8–15 cm × 4–8 cm, base rounded to slightly cuneate, apex abruptly acuminate, obtuse or minutely apiculate, entire, very thick-papery, glabrous, dark green

Gnetum buchholzianum – 1, branch with male inflorescences; 2, male inflorescence; 3, young infructescence; 4, female flower.
Redrawn and adapted by Achmad Satiri Nurhaman

above, paler beneath, with 4–8 pairs of strongly curved lateral veins looped near the margin. Inflorescence an unbranched catkin, axillary or terminal on a short branch, solitary but male inflorescences at apex of branches often in groups of 3, up to 8 cm long, jointed, peduncle 1–1.5 cm long, with 2–3 scale-like, triangular bracts; male inflorescence with thick internodes widening towards apex and with whorls of flowers at nodes; female inflorescence with slightly turbinate internodes and 3 flowers at each node. Flowers small, c. 2 mm long, with moniliform hairs at base and an envelope; male flowers with a tubular envelope and hardly exserted staminal column bearing 2 anthers; female flowers with cupular envelope and naked, sessile ovule. Seed resembling a drupe, ellipsoid, 10–15 mm × 4–8 mm, apiculate, enclosed in the fleshy envelope, orange-red when ripe, with copious endosperm.

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plemented with forest soil. Field planting, preferably next to a young tree or shrub, takes place at the beginning of the rainy season.

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Handling after harvest Leafy stems remain fresh for at least a week. Stems collected from the forest are brought to collecting points from where they are either sold in the local market or exported. For this trade, whole leafy stems are packed in large bales. Selection takes place for size and texture of the leaves, and is mainly determined by the species. *Gnetum buchholzianum* is more popular with consumers and more expensive because its leaves are generally thicker than those of *Gnetum africanum*. Leaves are shredded before consumption or prior to drying.

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Major references Keay, R.W.J., 1954b; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Schippers, R.R., 2000; Schippers, R.R. & Fereday, F., 1998; Shiembo, P.N., 1997; Shiembo, P.N., 1999.

Other references Asaha, S. et al., 2000; Burkill, H.M., 1994; Carlquist, S. & Robinson, A.A., 1995; Doweld, A.B., 2000; Friedman, W.E. & Carmichael, J.S., 1998; Lowe, J., 1984; Markgraf, F., 1930; Ouabonzi, A., Bouillant, M.L. & Chopin, J., 1983; Stevels, J.M.C., 1990.

Sources of illustration Keay, R.W.J., 1954b.

Authors R.R. Schippers

GONGRONEMA ANGOLENSE (N.E.Br.) Bullock

Protologue Kew Bull. 15: 199 (1961).

Family Asclepiadaceae (APG: Apocynaceae)

Synonyms *Marsdenia angolensis* N.E.Br. (1895), *Marsdenia gondarensis* Chiov. (1911).

Origin and geographic distribution *Gon-*

gronema angolense is widely distributed all over tropical Africa, from Guinea to Zimbabwe.

Uses In Rwanda the thick fleshy roots are eaten by children.

Properties There is no information on the phytochemistry of *Gongronema angolense*. Leaves of *Gongronema latifolium* Benth. (a related climber in wet forests in tropical Africa) have shown anti-inflammatory properties and antioxidant effects in hepatocytes of non-insulin dependent diabetic rats.

Botany Slender climber, often 3–4 m long, but able to climb to the canopy of high trees, with woody base and fleshy roots, containing latex. Leaves opposite, simple, softly hairy; petiole up to 4 cm long; blade ovate, 5–14 cm × 3–10 cm, base cordate, apex acuminate, margins entire. Inflorescence cymose, composed of 2–3 primary branches divided dichotomously, each division ending in a 10–14-flowered umbel. Flowers bisexual, small, regular, 5-merous, yellow-green; pedicel c. 1 cm long; sepals elliptical-oblong, c. 2 mm × 1 mm; corolla tubular, with campanulate tube up to 4 mm long, lobes elliptical-oblong, c. 2 mm long, spreading; corona lobes as long as stamens; stamens with deltoid to ovate anther appendages, connivent around the stout, roundish style apex. Fruit a pair of leathery, pendent follicles, each one cylindrical, 10–15 cm × 4–8 mm, densely brown-grey hairy.
Gongronema is a small genus comprising 5 species in Africa, much resembling *Dregea*, formerly described in *Marsdenia*.

Ecology *Gongronema angolense* is most abundant as a climber in secondary vegetation or in forest edges, in dry localities, from sea-level up to 1800 m altitude.

Genetic resources and breeding *Gongronema angolense* is common all over tropical Africa and is not in danger of genetic erosion.

Prospects More research is needed to determine the nutritive value of the fleshy roots of *Gongronema angolense*.

Major references Brown, N.E., 1902–1904; Bullock, A.A., 1961.

Other references Beentje, H.J., 1994b; Bullock, A.A., 1963; Burkill, H.M., 1985; Morebise, O. et al., 2002; Ugochukwu, N.H. & Babady, N.E., 2002.

Authors P.C.M. Jansen

GUIZOTIA SCABRA (Vis.) Chiov.

Protologue Annuario Reale Ist. Bot. Roma 8: 184 (1904).

Family Asteraceae (Compositae)

Chromosome number $2n = 30$

Origin and geographic distribution *Guizotia scabra* has been found, usually at middle and higher elevations, in Nigeria, Cameroon, DR Congo, Rwanda, Burundi, Sudan, Eritrea, Ethiopia, Kenya, Uganda, Tanzania, Malawi, Zambia, Zimbabwe and Mozambique. It has also been encountered in Yemen.

Uses The young, tender leaves are eaten boiled in Ethiopia, Uganda and Tanzania. In Ethiopia it is considered a famine crop, in Tanzania and Uganda it appears to be more acceptable. In Nigeria the leaves are eaten in soup and the seeds are pounded and eaten raw. In Ethiopia the seeds are used as a substitute for the seeds of the oil-seed crop *Guizotia abyssinica* (L.f.) Cass. and for ceremonial purposes. In Uganda the dry seeds are roasted and ground to make a paste that is mixed with green vegetables, peas or beans. A vegetable salt is made from the stems by burning, followed by purification.
The stem fibres are used in DR Congo for fishing-nets. The plant is reportedly grazed by livestock in Sudan but not in northern Kenya.
Medicinal uses have been reported from DR Congo, Rwanda, Burundi and Uganda. The leaves are used most frequently, but bark and roots are used as well. Among the human diseases and ailments treated with *Guizotia scabra* are: malaria, constipation, salmonella infection, ulcers, stomach-ache, dyspepsia, gastritis, enteritis, syphilis and gonorrhoea. In Uganda a root decoction is drunk to prevent miscarriage. In DR Congo *Guizotia scabra* has a wide range of veterinary applications against internal parasites (e.g. worms, amoebae), blood parasites (theileriosis or east coast fever, babesiosis) and external parasites (gadfly, botfly).

Botany Erect, perennial, moderately branching herb up to 2 m tall. Leaves opposite, simple, sessile; blade narrowly lanceolate to broadly oblanceolate, 5.5–10.5 cm × 1–3 cm, base cuneate-cordate, apex acute, margin entire to serrate. Inflorescence a cup-shaped head 9–15 mm in diameter, with (5–)8 outer involucral leaves; ray florets 8–15, female, tube 1.5–2.5 mm long, ligule 11–14 mm × 2.5–4.5 mm; disk florets 50–90(–120), bisexual, tube 1–1.5 mm long, limb 2.5–3 mm long. Fruit an achene 2–2.5 mm long.

Guizotia comprises 6 or 7 species all of them distributed in the mountains of eastern Africa. The exception is *Guizotia scabra*, which is also found in the highlands of Nigeria and Cameroon. The taxonomic position of three closely related species is not yet fully clear. The wild, annual species *Guizotia schimperi* Sch.Bip. is considered the ancestor of the cultivated oilseed crop *Guizotia abyssinica*. *Guizotia scabra* is distinguished from *Guizotia schimperi* by its perennial nature and the larger number of involucral leaves and ray and disk florets. *Guizotia schimperi* is, however, still considered by some taxonomists as a subspecies of *Guizotia scabra*. The huge variation observed in *Guizotia scabra* in the field, is attributed to a large extent to differences in growing conditions.

Ecology *Guizotia scabra* is found in a wide variety of soils. It has been encountered in swampy areas, wet and dry grassland, on stony hill slopes and as a ruderal. It flowers most abundantly shortly after the first rains, but flowers are found throughout the year. In Ethiopia *Guizotia scabra* is most common at 2500–3500 m altitude, whereas *Guizotia schimperi* is more frequent at 1500–2500 m. Germination is enhanced by burning.

Management *Guizotia scabra* is reportedly cultivated in Nigeria, Sudan and Ethiopia but no details have been published.

Genetic resources and breeding *Guizotia scabra* is common throughout its range and not in danger of genetic erosion. It is not reproductively separated from *Guizotia abyssinica*; so hybrids can be obtained with ease. In germplasm collections only few accessions are kept, all of them from Ethiopia.

Prospects *Guizotia scabra* will probably remain a minor vegetable of limited importance. Gene transfer from *Guizotia scabra* to the cultivated *Guizotia abyssinica* may prove of interest in breeding programmes. Collection of germplasm throughout the area of distribution of *Guizotia scabra* is desirable. The wide range of diseases treated with *Guizotia scabra* warrants research into the medicinal and pharmacological properties, notably those of the leaves. That medicinal uses are really restricted to the Great Lakes Region needs confirmation.

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Other references Burkill, H.M., 1985; Kokwaro, J.O., 1993; Umali, B.E. & Yantasath, K., 2001.

Authors C.H. Bosch

GYNURA PSEUDOCHINA (L.) DC.

Protologue Prodr. 6: 299 (1838).
Family Asteraceae (Compositae)
Chromosome number $2n = 20$
Synonyms *Gynura miniata* Welw. (1859).

Origin and geographic distribution *Gynura pseudochina* extends from Sierra Leone eastwards through the Central African Republic and Ethiopia to Somalia and south to Malawi, Zambia and Angola. It also occurs in Sri Lanka, India, Bhutan, China, Myanmar, Thailand, Vietnam and Australia. It is cultivated in Java (Indonesia) and Peninsular Malaysia.

Uses *Gynura pseudochina* is grown in eastern Nigeria for its mucilaginous leaves, which are used in soups and sauces.
In northern Nigeria it is cultivated as a medicinal plant to treat fever. The fresh leaves are used for their demulcent property, and leaf sap is applied to sore eyes. In Asia leaves are used to reduce skin irritation caused by insect stings, pimples and bruises, and to cure scabies and erysipelas. Leaves, stems and roots are variably credited with haemostatic, antipyretic and vulnerary activity. Plant parts are used to regulate menses, to treat breast tumours, herpes infections and sore throats. As an ornamental *Gynura pseudochina* is grown in pots.

Botany Perennial, erect, semi-succulent herb up to 130 cm tall; roots tuberous, round or lobed, 2–6 cm in diameter. Leaves in a rosette, simple, often shallowly lobed; petiole 0.3–3(–8) cm long; blade obovate, spatulate, elliptical or ovate, (1–)7–40 cm × (1–)1.5–20 cm; upper leaves more dissected and smaller. Inflorescence a campanulate head, loosely racemosely or paniculately grouped; peduncle up to 4 cm long; inner involucral bracts c. 13, 7–12 mm long; corolla 10–13 mm long, yellow to red. Fruit an achene, 3–4 mm long.
Gynura is placed in the tribe *Senecioneae* and comprises about 40 species, all native to the tropics of the Old World and temperate eastern Asia. In Africa 8 native species occur.

Ecology *Gynura pseudochina* occurs in grassland, usually among rocks, and in East Africa on black cotton soils.

Management Seed, cuttings or tubers can be used for propagation.

Genetic resources and breeding *Gynura pseudochina* is very widely distributed and not in danger of genetic erosion.

Prospects *Gynura pseudochina* will remain of some local importance as a vegetable and medicinal plant. For cultivation as a vegetable, Asian selections of *Gynura bicolor* (Roxb. ex Willd.) DC. might be introduced.

Major references Burkill, H.M., 1985; Davies, F.G., 1978; Jeffrey, C., 1986.

Other references Lean Teik Ng & Su Foong Yap, 2003.

Authors C.H. Bosch

HALOSARCIA INDICA (Willd.) Paul G.Wilson

Protologue Nuytsia 3: 63 (1980).

Family Chenopodiaceae (APG: Amaranthaceae)

Chromosome number $2n = 18, 27, 36$

Synonyms *Salicornia indica* Willd. (1799), *Arthrocnemum indicum* (Willd.) Moq. (1840).

Vernacular names Brown-headed glasswort, glasswort (En). Salicorne indienne (Fr). Machûr (Po).

Origin and geographic distribution *Halosarcia indica* is widespread in Australia and along the tropical coasts of the Indian Ocean. In Africa it occurs from Somalia southwards to Mozambique, Madagascar and the other Indian Ocean islands, perhaps also occasionally in the west along the coast of the Atlantic Ocean.

Uses After removing the woody and corky parts, young branches of *Halosarcia indica* collected from the wild are eaten as a cooked vegetable, particularly in times of food scarcity. In Madagascar young branches in vinegar are used as a condiment.

Botany Small, glabrous shrub, with prostrate main stem forming loose open mats and numerous ascending or erect lateral branches up to 30 cm long, seemingly leafless, built up of numerous superposed, tubular, green-glaucous segments, each segment at apex forming a little cup with 2 short lobes embracing the base of the next higher segment; sterile segments 5–11 mm × 3–6 mm; fertile segments aggregated into spikes 1–4 cm × 4–5 mm at the ends of stem and lateral branches. Flowers in clusters of 3, a pair of clusters to each fertile segment, all flowers female and small, hidden; perianth tubular, irregularly 3-lobed at apex, becoming spongy in fruit; ovary superior, 1-celled, stigmas 2, slender. Fruit a nut, hidden in ring-like, disarticulating segments of fruiting spikes. Seed lens-shaped to flattened ovoid, c. 1 mm long, testa membranous, pale brown.

Halosarcia comprises 23 species, all confined to Australia except the wider distributed *Halosarcia indica*. It resembles *Arthrocnemum*, *Salicornia* and *Sarcocornia*, but the first of these has more slender fruiting spikes and black seeds, the second differs in its habit, being annual herbs, and the third has fruiting spikes not disarticulating into ring-like segments and more exposed flowers. Within *Halosarcia indica* 4 subspecies have been distinguished; only subsp. *indica* is widespread, the other 3 are indigenous to Australia. Most probably parthenogenesis occurs because only female plants are known, which produce normal seed. The seeds are distributed in the floating ring-like segments that disarticulate from the fruiting spikes at maturity.

Ecology *Halosarcia indica* grows on tidal mud flats, in salt marshes near the sea and in mangrove swamps.

Genetic resources and breeding *Halosarcia indica* is widespread along coasts in the Old World tropics and is not in danger of genetic erosion.

Prospects *Halosarcia indica* will remain an interesting minor vegetable. Its use is comparable to *Salicornia*, which is a palatable and esteemed vegetable in some parts of Europe. Its nutritional value merits further investigation.

Major references Brenan, J.P.M., 1964; Brenan, J.P.M., 1988; Decary, R., 1946; Wilson, P.G., 1984.

Other references Ajmal Khan M. & Bilquees Gul, 1998; Friis, I. & Gilbert, M.G., 1993; Tölken, H.R., 1967.

Authors P.C.M. Jansen

HAUMANIASTRUM CAERULEUM (Oliv.) P.A.Duvign. & Plancke

Protologue Biol. Jaarb. 27: 225 (1959; '*coeruleum*').

Family Lamiaceae (Labiatae)

Chromosome number $2n = 28, 42, 56$

Synonyms *Acrocephalus caeruleus* Oliv. (1875), *Acrocephalus lilacinus* Oliv. (1875), *Haumaniastrum lilacinum* (Oliv.) J.K.Morton (1962), *Haumaniastrum quarrei* (Robyns & Lebrun) J.K.Morton (1962).

Origin and geographic distribution *Haumaniastrum caeruleum* is widely distributed in West, Central and East Africa; in southern

Africa it is found in Malawi, Zambia, Angola and Zimbabwe.

Uses The leaves of *Haumaniastrum caeruleum* are eaten as a vegetable in Sudan. The powdered leaves are put in water to sponge a person with high fever. The leaves are used to treat headache in Senegal and Ghana. The plant ash is used as a vegetable salt in Kenya. Mixed with oil the leaves are used as perfume in Sudan.

Botany Perennial herb up to 1 m tall; stem quadrangular, 1 to several arising from small woody rootstock or from fibrous root system. Leaves opposite or in whorls of 3–4, sessile or with short petiole up to 2 mm long; blade linear or narrowly elliptical, 2–10 cm × 0.2–1.5 cm, base attenuate or cuneate, apex acute, margin serrate. Inflorescence a globose to cylindrical head arranged in a lax or dense corymb; head 0.5–2(–4) cm long, subtended by white or bluish leaf-like caudate bracts up to 2.5 cm long. Flowers bisexual, zygomorphic, 5-merous; calyx 1.5–2 mm long, 2-lipped, enlarged in fruit; corolla 4–6 mm long, white, pink, blue or purple, 2-lipped, tube 3–4.5 mm long, lower lip 4-lobed; stamens 4; ovary superior, 4-lobed, style gynobasic, bifid at apex. Fruit consisting of 4 nutlets 1–1.5 mm long.

Haumaniastrum comprises 35 species and is confined to tropical mainland Africa, with a single species also occurring in Madagascar. *Haumaniastrum caeruleum* is very variable, with variation notably in leaf shape, colour of floral bracts and hair density and length. The variation is possibly related to the different ploidy levels reported.

Ecology *Haumaniastrum caeruleum* is found in moist localities in grassland and open woodland, and as a weed in fields, at 200–2100 m altitude.

Genetic resources and breeding As *Haumaniastrum caeruleum* is widespread and fairly common throughout its area of distribution there is no serious threat of genetic erosion.

Prospects *Haumaniastrum caeruleum* is likely to remain a minor vegetable and medicinal plant.

Major references Burkill, H.M., 1995; Morton, J.K., 1962; Paton, A., 1997a.

Other references Paton, A., 1997b.

Authors C.H. Bosch

HEWITTIA MALABARICA (L.) Suresh

Protologue Nicolson, Suresh & Manilal, Interpret. Van Rheede's Hort. malab.: 88 (1988).

Family Convolvulaceae

Chromosome number $2n = 30$

Synonyms *Convolvulus malabaricus* L. (1753), *Hewittia sublobata* (L.f.) Kuntze (1891), *Hewittia scandens* (J.König ex Milne) Mabb. (1980).

Origin and geographic distribution *Hewittia malabarica* is widespread throughout tropical Africa, Asia and Polynesia; it has been introduced and naturalized in tropical America (e.g. Jamaica).

Uses The leaves of *Hewittia malabarica* are collected from the wild and used as a cooked vegetable. In Uganda they are particularly popular among the Langi people in a dish known as 'onyebe'. The fibre from the inner bark is used for ropes. In Madagascar *Hewittia malabarica* is grown as a cover plant in plantations of ylang-ylang (*Cananga odorata* (Lam.) Hook.f. & Thomson) and is grazed by cattle.

Botany Climbing or prostrate perennial herb with slender stem up to 3 m long, occasionally rooting at the nodes, pubescent. Leaves alternate, simple; stipules absent; petiole up to 9 cm long; blade oblong to ovate, 2–14 cm × 1–10 cm, base cuneate, truncate or hastate, apex obtuse to acuminate, margin dentate or entire, pilose to velvety hairy. Inflorescence an axillary, 1–3-flowered cyme, bracteate; peduncle up to 10 cm long. Flowers bisexual, regular, 5-merous; pedicel up to 3 cm long; sepals lanceolate to ovate, up to 17 mm long, the outer 3 much larger than the inner 2; corolla campanulate to funnel-shaped, 2–3.5 cm long, slightly lobed, pale yellow or white with a purple centre, pilose outside in 5 bands; stamens inserted in corolla tube, included; ovary superior, 1-celled, hairy, style filiform, stigmas 2, ovate-oblong. Fruit a globose to quadrangular capsule c. 1 cm in diameter, pilose, enclosed by the enlarged sepals, usually 4-valved, 2–4-seeded. Seeds subglobose, 3–6 mm in diameter, black.

Hewittia is close to *Convolvulus*, which has linear stigmas. *Hewittia* comprises only a single species, of which the correct name is still disputed because of differences in interpretation of older literature.

Ecology *Hewittia malabarica* occurs in rainforest, mixed open forest, coastal littoral forest and scrub, along dry watercourses, in grass-

land and as a weed of cultivated land and along roadsides, from sea-level up to 1800 m altitude. In Uganda it occurs in areas with an annual rainfall of 1100–2100 mm.

Genetic resources and breeding *Hewittia malabarica* is very widespread and not liable to genetic erosion.

Prospects *Hewittia malabarica* will remain a locally popular minor vegetable, which is often available when other vegetables are scarce. Its nutritional composition and ornamental possibilities need further investigation.

Major references Burkill, H.M., 1985; Gonçalves, M.L., 1987; Katende, A.B., Ssegawa, P. & Birnie, A., 1999; Meeuse, A.D.J. & Welman, W.G., 1996.

Other references Deroin, T., 2001; Gonçalves, M.L., 1992; Verdcourt, B., 1963.

Authors P.C.M. Jansen

HIBISCUS ACETOSELLA Welw. ex Hiern

Protologue Cat. afr. pl. 1(1): 73 (1896).

Family Malvaceae

Chromosome number $2n = 72$

Vernacular names False roselle, red-leaved hibiscus, cranberry hibiscus, African rosemallow (En). Fausse oseille de Guinée (Fr). Azedas (Po).

Origin and geographic distribution *Hibiscus acetosella* is an amphidiploid species possibly originating from hybridization between *Hibiscus asper* Hook.f. and *Hibiscus surattensis* L., most probably in the region of southern DR Congo-Angola-Zambia. The hybridization may have occurred as a result of cultivation. *Hibiscus acetosella* is cultivated, but also occurs under natural conditions, usually in ruderal habitats, where it may have become naturalized after escape from cultivation. It is a popular vegetable in Cameroon and DR Congo. The crop was introduced to South-East Asia and to Brazil. In Brazil, where it was probably used as food for slaves, it is now more popular than in Africa. Red-flowered types with dark red leaves are mainly used as ornamentals and can be found throughout Africa as well as the tropics and subtropics of other continents.

Hibiscus acetosella – wild and planted

Uses The young, somewhat fleshy leaves and shoots are used as a vegetable. Yellow-flowered types with green leaves are most popular for this purpose, but red-flowered types with dark red leaves are also eaten. The leaves are mucilaginous and more sour than the similar looking *Hibiscus sabdariffa* L. and are used as a cooked vegetable, sometimes with pounded peanuts added to improve the flavour. The red leaves remain reddish after cooking. In South America, people often use types with decorative pinkish-brown leaves in fresh salads and appreciate their special rather sour taste. The red flowers and possibly also the leaves are occasionally used to make a tea, somewhat similar to the use of the red calyces of *Hibiscus sabdariffa* L. The root is edible but insipid and fibrous. Pink- or red-flowered types are often grown as ornamental plants in gardens. Some people in Cameroon and DR Congo combine the use of *Hibiscus acetosella* as a vegetable with its use as a hedge to separate plots. In Angola an infusion of the leaves in water is used as post-fever tonic; it is also used as medicine to treat anaemia. In East Africa children with an aching body are washed in cold water to which some mashed *Hibiscus acetosella* leaves have been added.

Production and international trade *Hibiscus acetosella* is mainly grown in small gardens, often in association with *Hibiscus sabdariffa*. Farmers combine these two species so that they can adjust the acidity of the final product to the wishes of the consumer and mixed bunches of the two species are often found in local markets. Mixtures of green-leaved and red-leaved types of *Hibiscus acetosella* with different taste are also found. Although the two *Hibiscus* species look very similar when green, people can distinguish them. No data on production are available and no international trade is reported.

Properties There is no information on the nutritive value of *Hibiscus acetosella* leaves, but it is probably comparable to that of the

related *Hibiscus sabdariffa* L. and *Hibiscus cannabinus* L.

Adulterations and substitutes The leaves of *Hibiscus cannabinus*, *Hibiscus sabdariffa* or other *Hibiscus* spp. can be used as a substitute for *Hibiscus acetosella* leaves in dishes.

Description Annual or perennial herb or subshrub up to 2(–2.5) m tall; stem glabrous to sparsely pubescent. Leaves alternate, simple; stipules very narrowly lanceolate to linear, up to 1.5 cm long; petiole 3–11 cm long; blade shallowly to deeply palmately 3–5-lobed but upper leaves sometimes undivided, up to 10 cm × 10 cm, margin crenate, glabrous or sparsely pubescent, palmately veined, with a distinct nectary at base of midrib. Flowers solitary in leaf axils, bisexual, regular, 5-merous; pedicel up to 1 cm long, articulate; epicalyx segments 8–10, bifurcate at apex, one fork lanceolate and spoon-shaped, the other linear, both c. 3 mm long; calyx campanulate, up to 2.5 cm long, lobes nearly glabrous; petals free, obovate, up to 5.5 cm × 3.5 cm, lemon-yellow with red-purple base or wine-red; stamens numerous, united into a column up to 2 cm long, red-purple; ovary superior, 5-celled, style with 5 branches. Fruit an ovoid capsule up to 2.5 cm long, almost glabrous to appressed-pubescent, many-seeded. Seeds reniform, c. 3 mm × 2.5 mm, dark brown. Seedling with epigeal germination; cotyledons rounded, up to 2 cm × 2 cm, leafy.

Other botanical information *Hibiscus* comprises 200–300 species, mainly in the tropics and subtropics; many of them grown as ornamentals. The estimated number of species varies because opinions differ about inclusion of several related groups of species in the genus. *Hibiscus acetosella* belongs to section *Furcaria*, a group of about 100 species which have in common a pergamentaceous calyx (rarely fleshy) with 10 strongly prominent veins, 5 running to the apices of the segments and bearing a nectary, and 5 running to the sinuses. Other species belonging to this section and used as vegetable are *Hibiscus asper* Hook.f., *Hibiscus cannabinus* L., *Hibiscus diversifolius* Jacq., *Hibiscus mechowii* Garcke, *Hibiscus noldeae* Baker f., *Hibiscus rostellatus* Guill. & Perr., *Hibiscus sabdariffa* L. and *Hibiscus surattensis* L. *Hibiscus acetosella* can best be distinguished from related *Hibiscus* species by its non-prickly stems, more or less glabrous leaves and bifurcate epicalyx lobes with lower fork spoon-shaped.

Growth and development *Hibiscus acetosella* is probably mainly self-pollinating. This is favoured by the flower structure, with style branches included in the staminal column or hardly exserted.

Hibiscus acetosella – 1, part of flowering twig; 2, fruit.
Source: PROSEA

Ecology *Hibiscus acetosella* occurs in abandoned fields and plantations, on waste ground near habitations, in marshes and forest clearings. It is cultivated at low to medium altitudes, usually in high rainfall areas, and requires good drainage. It can be fully exposed to the sun, but prefers some shade.

Propagation and planting Vegetable types of *Hibiscus acetosella* are almost always propagated by seed, whereas the use of cuttings is a more common method of propagation for ornamental types. Market gardeners propagate *Hibiscus acetosella* in the same way as more common *Hibiscus* leaf crops by broadcasting the seed, but some farmers sow in lines. It may also be grown as an intercrop. When grown in home gardens, people usually establish a small nursery, from where they transplant seedlings.

Management *Hibiscus acetosella* is frequently grown in home gardens, where people keep a few plants or grow it as a hedge from which they collect shoots when required. When grown on a larger scale as a vegetable, weeding is rarely necessary because it rapidly covers the ground after sowing, suppressing most weeds.

Diseases and pests *Hibiscus acetosella* is

highly resistant to root-knot nematodes and is therefore an excellent crop to be used after tomatoes or other solanaceous vegetables that are affected by nematodes.

Harvesting When the plants reach a size of about 25 cm, the first crop is harvested by uprooting, leaving remaining plants at a spacing of approximately 15 cm. Harvesting takes place early in the morning or late in the evening, allowing a fresh crop to arrive at the market. The next harvest is either by uprooting or by removing the tops only and allowing new side shoots to form. The latter process may be repeated 2 or 3 times, depending on soil fertility and the humidity of the soil.

Handling after harvest When *Hibiscus acetosella* is grown for the market, farmers make bundles of about 10 shoots of 40 cm long and these bundles may be bundled together again. At the market the leaves are sprinkled with water when there are signs of wilting. The crop's perishability does not allow for long-distance transport.

Genetic resources A limited number of accessions of *Hibiscus acetosella* are included in germplasm collections of *Hibiscus*, e.g. at the Southern Regional Plant Introduction Station, Griffin GA, United States. It is not in danger of genetic erosion.

Breeding *Hibiscus acetosella* is used to transfer nematode resistance to other *Hibiscus* species, e.g. *Hibiscus cannabinus*, and the closely related *Hibiscus radiatus* Cav. can be used as a bridging species since their hybrids are fertile.

Prospects *Hibiscus acetosella* remains a locally popular indigenous vegetable and may see some expansion. Agronomy and breeding merit more attention. It will probably become more important as an ornamental plant.

Major references Burkill, H.M., 1997; Katende, A.B., Ssegawa, P. & Birnie, A., 1999; Ruffo, C.K., Birnie, A. & Tengnäs, B., 2002; Stevels, J.M.C., 1990; Widodo, S.H., 1993; Wilson, F.D., 1999.

Other references Akpan, G.A., 2000; Hauman, L. & Wouters, W., 1963; Kokwaro, J.O., 1993; Vollesen, K., 1995b; Williamson, J., 1955.

Sources of illustration Widodo, S.H., 1993.

Authors R.R. Schippers

HIBISCUS ASPER Hook.f.

Protologue Hook., Niger Fl.: 228 (1849).

Family Malvaceae

Chromosome number $2n = 36$

Synonyms *Hibiscus cannabinus* L. var. *punctatus* (A.Rich.) Hochr. (1916).

Vernacular names Wild sorrel, false roselle (En). Roselle sauvage (Fr).

Origin and geographic distribution *Hibiscus asper* is widely distributed throughout tropical Africa and in Madagascar. It is occasionally cultivated as a vegetable, e.g. in Senegal and DR Congo.

Uses Leaves of *Hibiscus asper* are eaten as a boiled vegetable; this use is particularly widespread in the Sahel region. In Nigeria the young fruits are used to thicken soup. *Hibiscus asper* is also used for its fibre, e.g. in Senegal. It is considered an important fodder plant in the Sahel and although eaten by all livestock, camels especially appreciate it. If eaten in excess it can cause bloat in cattle. It is unsuitable for making hay but can be used for making silage. The seeds form a main part of the diet of wild guinea fowl in northern Cameroon and are likely equally important for domestic poultry.
Leaves dried over a fire are applied to eczematous sores in Senegal. Various other skin problems of humans and domestic animals are treated with the leaves in Senegal, Guinea and Mali. The plant is used to treat urethritis in northern Nigeria, anaemia and jaundice in Benin and leucorrhoea in Cameroon. In addition, it is used as a poison antidote in Nigeria, to treat malaria in Mali and Benin, angina in the Central African Republic and painful and irregular menstruation in Benin, as a depurative and diuretic in Mali, as a tonic and restorative in Benin, and to control internal parasites in veterinary medicine in Guinea.

Properties The plant is mucilagenous in water and the sap is slightly acid. There is no information on the nutritive composition of *Hibiscus asper* leaves, but it is probably comparable to that of the related *Hibiscus cannabinus*. The composition of plants used for fodder per 100 g dry matter is: crude protein 31 g, crude fat 3.5 g, crude fibre 13.5 g, P 0.09 g, K 1.1 g, Ca 1.1 g, Mg 0.4 g, Na 0.01 g. The seeds contain per 100 g: water 64.2 g, fat 15.2 g, N 4.2 g, P 0.8 g, K 1.3 g, Ca 0.3 g, Mg 0.4 g, Na 0.07 g.

Botany Perennial herb up to 2 m tall; stem with fine prickles and simple or stellate hairs. Leaves alternate, simple; stipules threadlike,

up to 6 mm long; petiole 0.5–18 cm long; blade lanceolate to ovate, unlobed or shallowly to deeply palmately 3–5(–7)-lobed, up to 18 cm × 14 cm, margin serrate or slightly sinuate, with 2-fid stellate hairs on ribs and veins, palmately veined, with a distinct nectary at base of midrib. Flowers axillary, solitary or clustered, bisexual, regular, 5-merous; pedicel up to 1 cm long, articulate; epicalyx of 6–7 subulate segments 9–18 mm long, apex entire; calyx campanulate, up to 2.5 cm long, ribs of lobes with fine prickles or bristles; petals free, obovate, up to 4.5 cm × 3 cm, pale yellow with red-purple base; stamens numerous, united into a column up to 1.2 cm long, dark pink; ovary superior, 5-celled, style with 5 branches, included in the staminal column. Fruit an ovoid capsule up to 2 cm long, sparsely and finely appressed-pubescent, many-seeded. Seeds reniform, up to 4 mm × 3 mm, dark brown.

Hibiscus comprises 200–300 species, mainly in the tropics and subtropics. *Hibiscus asper* belongs to section *Furcaria*, a group of about 100 species, of which about 30 in tropical Africa, having in common a pergamentaceous calyx (rarely fleshy) with 10 strongly prominent veins, 5 running to the apices of the segments and 5 to the sinuses. The leaves of several other species of section *Furcaria* are more well-known vegetables: *Hibiscus acetosella* Welw. ex Hiern, *Hibiscus cannabinus* L., *Hibiscus sabdariffa* L. and *Hibiscus surattensis* L. *Hibiscus mechowii* Garcke is cultivated as a vegetable in DR Congo and is used as a vegetable, cough medicine and for its fibre in Zambia. The leaves of *Hibiscus noldeae* Baker f. are eaten in DR Congo, Zimbabwe and Tanzania, whereas cordage is made from the bast fibre in DR Congo.

Hibiscus asper can be distinguished from related *Hibiscus* species by its stems with fine prickles, poorly developed vegetative branches, narrow epicalyx lobes which are not bifurcate, and a calyx with nectary, white woolly hairs and curved prickles or bristles. *Hibiscus asper* was and sometimes still is considered conspecific with *Hibiscus cannabinus*. It is probably mainly self-pollinating. This is favoured by the flower structure, with style branches included in the staminal column or hardly exserted.

Ecology *Hibiscus asper* is found in fallow fields, grassland and edges of gallery forest. As a weed it is not considered very harmful in its area of origin.

Genetic resources and breeding In Senegal a locally selected type of *Hibiscus asper* with narrow leaves is cultivated on a small scale. Very few accessions are held in germplasm collections. As *Hibiscus asper* is widespread and often abundant, it is not in danger of genetic erosion.

Prospects *Hibiscus asper* will continue to be a minor vegetable of local importance, especially in the Sahel region. The possible use in breeding of commercially more important *Hibiscus* spp. has so far been neglected.

Major references Baerts, M. & Lehmann, J., 2002e; Bartha, R., 1990; Burkill, H.M., 1997; Wilson, F.D., 1999.

Other references Akpan, G.A., 2000; Akpan, G.A. & Hossain, M.G., 1998; Hochreutiner, B.P.G., 1955; Njiforti, H.L., Hebou, L. & Bodenkamp, A., 1998; Tollens, E., 2003; Vollesen, K., 1995b.

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HIBISCUS CALYPHYLLUS Cav.

Protologue Diss. 5: 283 (1788).

Family Malvaceae

Chromosome number $2n = 80$

Synonyms *Hibiscus calycinus* Willd. (1800).

Vernacular names Lemon-eyed rose mallow (En).

Origin and geographic distribution *Hibiscus calyphyllus* is widely distributed in Central, East and southern Africa, Madagascar and the Mascarene Islands, and occurs also in South Africa and Yemen. In Hawaii it is cultivated and naturalized in low-elevation dry areas. Elsewhere in the tropics and subtropics it is cultivated as an ornamental.

Uses The leaves of *Hibiscus calyphyllus* are eaten as a vegetable, especially in East Africa. They are collected from the wild during the rainy season, wilted, chopped and boiled mixed with other coarse vegetables. This vegetable is eaten frequently locally, but in small amounts. In Uganda poles made from the stems are used for building by the Karamajong people. The bast fibre is made into rope in Uganda and Tanzania. *Hibiscus calyphyllus* is cultivated throughout the tropics and subtropics as an ornamental. In DR Congo the leaves are used in a mixture with several other plant species to prepare a cure for ganglions in domestic animals. In Kenya and Tanzania the leaves are applied to wounds as a dressing. The vapour of boiled roots is inhaled and the decoction drunk to treat pneumonia.

Botany Perennial herb or shrub up to 3 m

tall; stem with long hairs. Leaves alternate, simple; stipules threadlike, up to 1.5 cm long; petiole up to 9(–18) cm long; blade broadly ovate to orbicular, sometimes shallowly 3-lobed, up to 19 cm × 19 cm, base slightly cordate, apex acute, margin serrate, with stellate hairs. Flowers solitary in leaf axils, often congested at ends of branches, bisexual, regular, 5-merous; epicalyx segments 5, variable in shape, apex entire; calyx campanulate, up to 2 cm long; petals free, obovate, up to 6 cm long, pale yellow with red or purple base; stamens numerous, united into a column up to 1.2 cm long; ovary superior, 5-celled, style with 5 branches, included in the staminal column. Fruit an ovoid, beaked capsule up to 2.5 cm long, densely hairy, many-seeded. Seeds reniform, c. 4 mm × 3 mm long, shortly hairy.

Hibiscus comprises 200–300 species, mainly in the tropics and subtropics. *Hibiscus calyphyllus* belongs to section *Calyphylli*, which is characterized by its epicalyx of 5 segments. *Hibiscus calyphyllus* and *Hibiscus ovalifolius* (Forssk.) Vahl are sometimes considered conspecific, but might well prove to be distinct. The Hawaiian plants assigned to this species possibly deserve specific rank. *Hibiscus calyphyllus* does not occur at low altitudes and records of uses and properties of *Hibiscus* from the coast of East Africa probably do not refer to this species. Until a proper revision of section *Calyphylli* becomes available, identification of species remains difficult.

Ecology *Hibiscus calyphyllus* occurs in rainforest, riverine forest, thickets and grassland, along roadsides and on fallow land, up to 2100 m altitude. In Tanzania it grows in areas with an annual rainfall of 1100–1600 mm.

Management As a weed *Hibiscus calyphyllus* is not very important but it is an important host for the cotton pest spiny bollworm (*Earias* spp.). Wherever transgenic cotton with the Bt gene is grown, *Hibiscus calyphyllus* populations can be useful in conserving susceptible genes in the bollworm population to counteract resistance of the pest against the toxin produced by the transgenic cotton plants.

Genetic resources and breeding There are few accessions of *Hibiscus calyphyllus* in genebanks. In its area of distribution the species is fairly common and not under threat of genetic erosion.

Prospects *Hibiscus calyphyllus* will remain a minor vegetable with only local importance. A taxonomic revision of *Hibiscus* is badly needed to avoid confusion in identifying species. Only *Hibiscus* section *Furcaria* has been revised recently, and even the delimitation of the genus and its sections is still unclear.

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Authors C.H. Bosch

HIBISCUS CANNABINUS L.

Protologue Syst. nat. ed. 10(2): 1149 (1759).

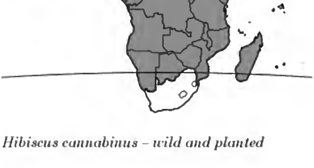
Family Malvaceae

Chromosome number $2n = 36$

Synonyms *Hibiscus sabdariffa* L. subsp. *cannabinus* (L.) G. Panigrahi & Murti (1989).

Vernacular names Kenaf, vegetable kenaf, Guinea hemp, Deccan hemp (En). Kénaf, chanvre de Guinée, chanvre de Bombay, da (Fr). Nacacha, nhacandora, cânhamo brasileiro (Po).

Origin and geographic distribution *Hibiscus cannabinus* is a common wild plant in most African countries south of the Sahara. It may have been domesticated as a fibre plant already 6000 years ago in Sudan. Kenaf is now widespread in the tropics and subtropics. As a vegetable it is widely grown in Africa, where it is grown on a much smaller scale as a fibre crop. In the past it has been of some importance as a commercial fibre crop in Côte d'Ivoire, Burkina Faso, Togo, Benin, Niger, Kenya, Tanzania and Malawi. India has long



Hibiscus cannabinus – wild and planted

been the largest producer of kenaf fibre.

Uses The shoots or young leaves, and sometimes the flowers and young fruits, are used as a vegetable. In Uganda a local delicacy is made from the seeds. These are roasted, ground and pounded, and the flour and skin are separated in water. The flour is rejected but the floating skin parts are used for the preparation of a paste, mixed with boiled pigeon peas. Children chew the bark for its sweetness. The stem is a source of fibre used in the manufacture of twine, rope and coarse textiles for sacking and cloth for packaging; special fibre cultivars exist. The production of kenaf fibre in Africa is rather uncommon, but locally important, e.g. in northern Nigeria, Niger and Sudan, where it is used for cordage, twines, fishlines and nets. Dried scraped ribbons are used for twine and cordage for sleeping mats. Ribbons and whole stems are a raw material for the pulp and paper industry. Seeds from the fibre crop are used for oil extraction, the rest being used as feed. The oil is suitable as a lubricant and for illumination, for manufacture of soap, linoleum and in paints and varnishes.

In local medicine in Kenya, pounded roots are administered to spider bites, and leaves are used to treat stomach disorders. In West Africa, powdered leaves are applied to sores and boils, and a leaf infusion is administered for treating cough. In India, juice from the flowers is taken against biliousness, while the seed are considered stomachic and aphrodisiac. Whole young plants are an excellent fodder for cattle. The stem core (xylem) is used in combination with peat moss (*Sphagnum*) and fertilizers as a growth medium for plants. Kenaf plants accumulate minerals such as selenium and boron and can be used as a bioremedial tool for removing these metals from contaminated soil. In West Africa the plants are used as boundary markers.

Production and international trade Kenaf leaves are sold at local markets in West and Central Africa. Statistics on production and trade as a vegetable are not readily available.

World production of kenaf fibres is estimated at 400,000 t/year averaged over 1997–2001. India is by far the largest producer (230,000 t/year). In Africa, production is limited and practically all kenaf fibre is produced domestically. Industrial production is reported from Nigeria and Sudan.

Properties The composition of kenaf leaves per 100 g edible portion is: water 79.0 g, energy 280 kJ (67 kcal), protein 5.5 g, fat 1.2 g, carbohydrate 12.2 g, fibre 2.3 g, Ca 484 mg, P 18 mg, Fe 12.1 mg, ascorbic acid 75 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). The composition of kenaf leaves is comparable to other dark green leafy vegetables.

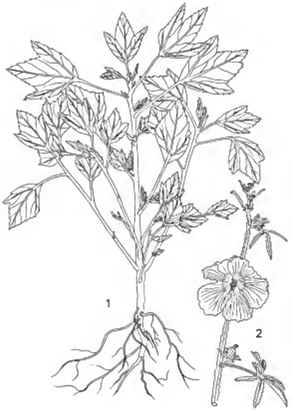
Kenaf produces a bast fibre similar to jute, but with a greater tensile strength, somewhat coarser and more brittle. On a dry weight basis the bast fibre content of the stem ranges from 21% in wild accessions up to 36% in modern cultivars. Individual bast fibres are (1.5–)2–3(–12) mm long and (7–)15–25(–41) μm in diameter with a cell wall thickness of 4–9 μm. Paper made from kenaf bast fibre by chemical pulping is stronger than paper from softwood pulp; paper made from whole stems by chemical pulping has strength properties between paper made from chemical pulp from softwood and that made from hardwood; it is comparatively tight and nonporous compared to paper made from wood.

Seeds contain up to 22(–26)% oil, with a fatty acid composition of palmitic acid 14–20%, stearic acid 3–7%, oleic acid 28–51% and linoleic acid 23–46%. The oil has phytotoxic and fungitoxic properties. The presscake contains: moisture 9%, crude protein 32%, oil 8%, crude fibre 8% and practically no antinutritional components.

Adulterations and substitutes Kenaf leaves in dishes can be replaced by roselle (*Hibiscus sabdariffa* L.) or other leafy vegetables.

For many purposes, such as packaging and cordage, kenaf, jute (*Corchorus capsularis* L.), roselle (*Hibiscus sabdariffa* L.) and congo jute (*Urena lobata* L.) may be substituted for each other, although kenaf and roselle are coarser and therefore cheaper than jute.

Description Annual herb, up to 2 m tall in the wild, up to 5 m in cultivars; taproot well developed, with lateral roots spreading horizontally to 1 m and adventitious roots on lowest stem section; stem erect, slender, cylindrical, prickly on wild accessions. Leaves alternate, simple; stipules filiform, 5–8 mm long, pubescent; petiole 3–30 cm long; blade 1–19 cm × 0.1–20 cm, very shallowly to very deeply palmately 3–7-lobed in lower part of plant, often unlobed in upper part or even bractlike near the apex, base cuneate to cordate, apex acuminate, margins serrate or dentate, upper surface glabrous but with a prominent, 3 mm long nectary at the base of the midrib, lower surface hairy along the veins. Flowers axillary, solitary or sometimes clustered near the apex of the plant, bisexual, 5-merous, 7.5–10 cm in



Hibiscus cannabinus – 1, habit of young plant; 2, flowering shoot.
Redrawn and adapted by Achmad Satiri Nurhaman.

diameter; pedicel 2–6 mm long, articulated at the base; epicalyx of 7–8 linear segments 7–18 mm long, persistent; calyx campanulate with acuminate to subcaudate lobes 1–2.5 cm long (up to 3.5 cm in cultivars), persistent, green, bristly and with a characteristic white, woolly, arachnoid tomentum especially near the base and margins, with a prominent nectary gland on each midrib; petals free, usually spreading, twisted clockwise or anticlockwise, obovate, 4–6 cm × 3–5 cm, outer side stellate-pubescent, usually cream to yellow with red inner base, sometimes blue or purple; stamens numerous, filaments united into a column surrounding the style, 17–23 mm long, dark red, with yellow or red anthers; ovary superior, ovoid, villose, 5-celled, style branching into 3–5, hairy arms 2–4 mm long, each branch ending in a capitate stigma. Fruit an ovoid, shortly beaked capsule 12–20 mm × 11–15 mm, densely appressed pubescent, 20–25(–35)-seeded. Seeds reniform to triangular with acute angles, 3–4 mm × 2–3 mm, grey to brown-black with pale yellowish spots, hilum brown. Seedling with epigeal germination.

Other botanical information *Hibiscus* comprises 200–300 species, mainly in the tropics and subtropics, many of which are grown as ornamentals. The estimated number of species varies because opinions differ about inclusion or exclusion of several related groups of species in the genus. Kenaf belongs to *Hibiscus* section *Furcaria*, a group of about 100 species which have in common a pergamentaceous calyx (rarely fleshy) with 10 strongly prominent veins, 5 running to the apices of the segments and bearing a nectary, and 5 to the sinuses. Interspecific hybridization has been attempted with variable success between *Hibiscus cannabinus* and other species within the same section, such as *Hibiscus sabdariffa* L., *Hibiscus radiatus* Cav., *Hibiscus diversifolius* Jacq. and *Hibiscus acetosella* Welw. ex Hiern.

Hibiscus cannabinus can easily be distinguished from the related species *Hibiscus sabdariffa* by the white, arachnoid tomentum on the calyx. *Hibiscus cannabinus* is very variable and various subclassifications have been proposed, but none is generally accepted. The vegetable types such as 'Malakwang' grown in Uganda have a bushy form.

Growth and development In general kenaf is an obligate short-day plant. Flowering is influenced by the time of planting; long days and high temperatures prolong the vegetative growth phase, an advantage for vegetable and fibre crops. Most cultivars remain vegetative until the photoperiod falls below 12.5 hours. In Ghana, day-neutral early maturing varieties exist that take 45–56 days from sowing to flowering.

Kenaf is mainly an out-breeding plant, but up to 30% self-pollination occurs. Flowers open before daybreak and begin to close about midday. The flower structure promotes cross-pollination. The pistil is functional when the flower opens, while the stamens are not dehiscing until shortly after sunrise. While the pistil is still functional, the stigmatic lobes hang down, almost touching the unopened anthers. Later in the day, the stigmatic lobes become turgid and soon stand above the anthers, which lose their pollen. Cross-pollination is mainly effected by insects such as bees. Seeds ripen in about 5 weeks after anthesis. In wild and vegetable types the fruit wall bursts and the seeds are spread on the ground, whilst in fibre types the fruits are indehiscent.

Ecology Kenaf grows naturally in grassland and as a weed in fields and wasteland. It is grown from sea level up to an altitude of 2700

m but does not do well above 2500 m and does not tolerate frost. It does well at day temperatures between 16°C and 27°C with 500–625 mm rainfall distributed over a period of 4–5 months. Lower temperatures retard plant growth. It does best on well-drained, neutral sandy loams, rich in humus. It does not tolerate waterlogging.

Propagation and planting Kenaf is usually propagated from seed but may also be propagated through cuttings. Seed yield is 1–28 g/plant; the 1000-seed weight 25–27 g, in wild forms only 9–12 g. Under ordinary storage conditions at ambient temperatures and humidity, seeds remain viable for about 8 months. The optimum temperature for seed germination is about 35°C. In home gardens or on small plots of vegetable kenaf, seeds are sown two or three at a time, at spacings of 15 cm × 15 cm. This system is also used when interplanting with other crops. Commercial farmers may broadcast the seed for a crop that will be uprooted once the stems are 20–30 cm long. For ratoon cropping farmers usually sow in rows 30 cm apart. After a first thinning the within-row spacing is 5–7 cm. Germination of untreated seed takes about 7 days, longer than for most vegetables; for this reason some farmers soak their seed in water for 24 hours prior to sowing, obtaining emergence after 3 days. The latter method can only be used when rain is expected soon after sowing or when irrigation facilities are available.

For fibre production kenaf is broadcast at a seed rate of 15–25 kg/ha or drilled at a spacing of 20–30 cm between rows and a 5–10 cm within rows, but somewhat wider to produce fibre for making paper. Broadcast crops require thinning to about 400,000 plants/ha.

Management Kenaf responds well to fertilizers and organic manure, but only farmers producing for the market are prepared to invest in this crop. Manure at a rate of 10–20 t/ha is preferred, but if it is not available, an initial application of 250 kg/ha compound fertilizer (e.g. NPK 15–15–15) is recommended. An additional application of nitrogen as side dressing of 50 kg/ha is needed after the first cutting, and this can be repeated after every harvest. Ratoon crops can be picked up to five times when adequate fertilizer is provided. Kenaf may be grown alone or intercropped with other plants. In some regions it is semicultivated as a protected weed for use as a vegetable.

Kenaf grown for fibre grows rapidly and requires little weeding after the first month after sowing.

Diseases and pests Diseases and pests of vegetable kenaf are the same as reported for the fibre crop, and most of them are also similar to these of cotton and okra. The main diseases are: foot, stem and collar rot and wilting caused by *Phytophthora*; *Sclerotium rolfsii* causing collar rot; powdery mildew caused by *Leveillula taurica*; *Coniella musaiaensis* causing leaf spot; *Selenosporella* species causing root rot and wilting; *Rhizoctonia solani* causing stem rot and lodging; *Pythium deliense* causing root rot; *Phomopsis* species causing stem spot; *Verticillium dahliae* causing wilting; *Fusarium oxysporum* causing wilting and necrosis; tobacco necrosis virus (TNV); and hibiscus latent ringspot virus (HLRSV), which is seed transmitted.

The cotton flea beetle *Podagrica puncticollis* is a notable pest, most serious in the seedling stage. *Oxycarenus* spp. and *Dysdercus superstitiosus* are seed infesting bugs. Kenaf is especially susceptible to root-knot nematodes (*Meloidogyne* spp.) that may reduce growth and yield especially on light-textured soils. Nematodes also predispose affected plants to pathogenic soil fungi. In order to control nematodes, crop rotation is recommended especially with amaranth or a cereal crop, and liberal application of organic fertilizer. Chemical spraying for control of pests and diseases is rarely applied.

Harvesting Vegetable kenaf takes 3–4 weeks from emergence to the first harvesting. As a first thinning, plants of about 20 cm are pulled up and marketed with their roots attached. When ratoon cropping is practised, the second harvest is at the 6-week stage, 2–3 weeks after the thinning round. Cutting is done at a height of 6–8 cm, leaving 3 leaves and buds for regrowth. Up to 4–5 harvests may be carried out at 2–3-week ratooning intervals. After that, the remaining loose leaves are collected for home consumption. In commercially grown broadcast crops whole plants are pulled up when 20–30 cm tall and are sold at the market with their roots attached.

The recommended time of harvesting kenaf as a fibre crop for an optimum balance in fibre yield and quality is when about 50% of the plants are flowering. Plants are cut near the ground and tied into loose bundles that are placed upright in the field for 2–3 days to induce defoliation and drying. Stems are then graded and tied into bundles of about 10 kg and of even stem thickness.

Yield The yield for once-over harvest as a vegetable by uprooting is 20–30 t/ha. For ratoon cropping, a total of 60 t/ha is feasible from 5 harvest rounds, depending on soil fertility and moisture. The highest yields are obtained from the second and third cuts.
World yield of kenaf as a fibre crop averages about 1.2 t dry fibre per ha. The potential yield, obtained in experimental fields with improved cultivars, is 3–5 t dry fibre per ha.

Handling after harvest Fresh shoots are easily transported and can be kept in good condition for 1–2 days especially in shade or cool places. Sprinkling with water helps to keep the leaves fresh. Leaves can be preserved by sun-drying. The dried product is broken into small pieces or ground to powder and used in soups.
For fibre production kenaf stems are usually retted in clear and slow-moving water for a period of 10–15 days at temperatures above 30°C to liberate the fibres from the bark. Sometimes stems are decorticated ('ribboned') and only the ribbons are steeped in water, cutting retting time by half. When retting is complete, the fibres are stripped manually from the stems, washed thoroughly in clean water and dried well in dust- and sand-free conditions. The dried fibres are transported in crude bales of 60–150 kg to the spinning mills. Whole stems may also be transported to pulp- and paper-making factories. Kenaf can be pulped by chemical, semi-chemical and mechanical processes. The alkaline sulphite-anthraquinone process is suitable for kenaf bark and whole stems, giving better yield, strength, viscosity and brightness of the pulp than soda and soda-anthraquinone pulping.

Genetic resources Local landraces of vegetable kenaf are presently not at great risk of genetic erosion, but the genetic variability in fibre cultivars is narrow. In Africa no major collections of kenaf have been reported. The Crop Research Institute in Kumasi, Ghana, has a germplasm collection of local cultivars of the vegetable type. In other countries (India, Bangladesh) large collections of kenaf as fibre crop are maintained. The Bangladesh Jute Research Institute (BJRI) at Dhaka, Bangladesh, has been designated as the world germplasm depository for kenaf and maintains a collection of some 920 accessions, including old and new cultivars, landraces, wild and semi-wild accessions of kenaf and related species.

Breeding Almost no research has been carried out to enhance the genetic potential. The existing landraces are mixtures of genotypes; the available diversity should be studied and selections made from the desirable types. Purple-flowered strains and the purple false roselle (*Hibiscus acetosella*) are resistant to the main disease of kenaf, root-knot nematodes; hence they are potential sources of desirable genes in breeding programmes.
Breeding of fibre cultivars with high potential yields under suboptimal conditions is urgent as kenaf grown for fibre is being pushed increasingly towards marginal environments. Other breeding objectives are plants without prickly stems and bristly capsules to facilitate harvesting, and resistance to diseases, nematodes and pests.

Prospects Kenaf is a high-yielding and increasingly popular vegetable for the city markets. Contrary to the popular roselle (*Hibiscus sabdariffa*), it can be grown near the equator. At present its main constraint is its sensitivity to nematodes. If this problem can be solved, vegetable kenaf may well face a bright future.
Kenaf fibre is a biodegradable and environment-friendly raw material suitable for many applications, such as woven and non-woven fabrics, geotextiles and semi-rigid and laminated sheets for packaging and panelling. Kenaf stems are an excellent substitute for softwood as raw material for the pulp and paper industry. Prospects for increased kenaf fibre and pulp production are good in view of growing concerns about environmental pollution and dwindling forest resources.

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Sources of illustration Nabakooza, J., 2003a.

Authors R. Bukenya-Ziraba

HIBISCUS SABDARIFFA L.

Protologue Sp. pl. 2: 695 (1753).
Family Malvaceae
Chromosome number $2n = 72$

Vernacular names Roselle, Jamaican sorrel, Indian sorrel, bissap, karkadeh (En). Oseille de Guinée, roselle, thé rose d'Abyssinie, groseille, karkadé (Fr). Vinagreira, azeda de Guiné, quiabeiro azedo (Po). Ufuta, ufuta dume (Sw).

Origin and geographic distribution *Hibiscus sabdariffa* probably originates from Africa, where it may have been domesticated in Sudan about 6000 years ago, first for its seed and later for leaf and calyx production. In the 17th century vegetable types were introduced to India and the Americas. Selection for fibre production took place in Asia, where cultivation is reported from the beginning of the 20th century, e.g. in India, Sri Lanka, Thailand, Malaysia and Java. Roselle is now found throughout the tropics. In tropical Africa it is especially common in the savanna region of West and Central Africa. It is often found as an escape from cultivation. However, apparently truly wild plants of *Hibiscus sabdariffa* have been collected in Ghana, Niger, Nigeria and Angola.

Uses In Africa roselle has two main uses: as a vegetable and for preparation of a beverage. Young roselle shoots, leaves and calices are used as a cooked vegetable or finely cut and used in sauces. The leaves and fresh green calices are used to make a soup, which is rather mucilaginous in texture. Freshly harvested leaves and/or calyces are also added to water-based sauces; oil, salt, onions, dried fish and hot pepper are often added. The sauces are eaten with tuber or cereal porridges or rice. Green roselle types are more appreciated for use as a cooked vegetable than red types, which are more commonly used in sauces. In some areas the leaves are mixed with groundnut or sesame paste. The stewed calyces of the green type are added as a condiment ('bëkëj') to rice dishes in Senegal. In the United States leaves and young shoots are also eaten raw in salads and the red fleshy calyx lobes are chopped and used in fruit salads, but these uses are not common in Africa. In Côte d'Ivoire the dried calyces ground to powder are used in sauces during the dry season.

Hibiscus sabdariffa – planted

The dried red calyces are commonly used to prepare a tea, drunk hot or, more commonly, cold after adding sugar. It is a sour tasting, refreshing drink, very popular from Senegal to Sudan and in Egypt and other northern African countries where it is referred to as 'karkadé'. Juice is often sold chilled or frozen as 'bissap' (Senegal) or 'da bilenni' (Côte d'Ivoire, Mali, Burkina Faso) along highways and in urban markets. Mint or ginger is sometimes added when boiling the calyces, particularly if the juice is to be sold frozen. The calyces are also boiled down to make a syrup concentrate. Due to their high inherent pectin content, roselle jams and jellies are also popular, particularly in Senegal, the Caribbean region and southern Asia. The dried calyces are used in Western countries as a base for many herbal teas and as a source of red food colorants. Following calyx harvest in West Africa, roselle plants are often used as fodder for livestock.

The oil of roselle seed is extracted and used for cooking, e.g. in Chad, Tanzania and China. However, the seed oil is claimed to contain some toxic substances and may be better used in the soap and cosmetics industries. Locally, the seeds are eaten roasted as a snack or ground into meal. In the Plateau region of Nigeria people ferment roselle seeds to make a cake used as 'sorrel meat'. The oil is also used as an ingredient of paints.

Roselle tea is used to suppress high blood pressure. The leaves are a source of mucilage used in pharmacy and cosmetics. Extracts are often used medicinally to treat colds, toothache, urinary tract infections and hangovers. Leaf juice is used to treat conjunctivitis in Senegal. Leaves are applied as a poultice to treat sores and ulcers. A root decoction can be used as a laxative.

As in Asia, roselle fibre is locally used in West Africa, but on a very small scale. The bast fibre

is a good substitute for jute and it is used for making twine, cordage, rope, netting and sacks. The bast fibre and sometimes also the whole stem are used in the paper industry in the United States and Asia. The ornamental value of roselle is of recent interest, as a garden plant or cut flower. The decorative red stalks with ripe red fruits are exported to Europe where they are used in flower arrangements.

Production and international trade Roselle is an important leafy vegetable in the drier parts of West and Central Africa. In Senegal, Mali, Chad and Sudan large quantities of calyces are produced for the preparation of beverages. Sudan is the major country in tropical Africa producing dried roselle calyces for local consumption and export, mainly in the Kordofan and Darfur regions in the west of the country. Production of roselle leaves and calyces for domestic consumption in Africa has not been quantified, although these are common products on local markets.

International trade of roselle calyces has increased steadily over the last decades, with 15,000 t/year now entering the world market. Germany and the United States are large importers. In 1998, United States and German importers paid 1200–1700 US$/t for Egyptian and Sudanese roselle; prices of Chinese roselle were lower. Prices fluctuate due to high variability in supply. A decrease in product quality in Thailand and China due to excessive precipitation caused world prices to soar to 4000 US$/t in 2003.

Sudan is the most important roselle producer in Africa, the annual area fluctuating between 11,000 ha and 57,000 ha depending on the amount of rainfall and prices. In 1995 Sudan reported exports of 32,000 t. In Sudan smallholder farmers traditionally grow roselle in plots ranging from under 0.25 ha to 2 ha, but some growers have up to 20 ha. Sudanese roselle is viewed as superior quality, but the United States trade embargo and large-scale production in Mexico, Thailand and China has led to shifts in the market. Jamaica and Egypt also export roselle. Senegal and Mali are also major producers, but the vast majority of their production is for domestic consumption or sold on the local markets. Fluctuations in export prices for cash crops such as cotton have led many West African farmers to diversify production, e.g. by growing roselle for the domestic market. In Asia roselle is primarily a fibre crop, accounting for 20% of jute-like fibre production or 700,000 t/year.

Properties The nutritional composition of roselle leaves per 100 g edible portion is: water 85.6 g, energy 180 kJ (43 kcal), protein 3.3 g, fat 0.3 g, carbohydrate 9.2 g, dietary fibre 1.6 g, Ca 213 mg, P 93 mg, Fe 4.8 mg, β-carotene equivalent 4135 μg, thiamin 0.2 mg, riboflavin 0.45 mg, niacin 1.2 mg, ascorbic acid 54 mg. The composition of fresh raw calyces per 100 g edible portion is: water 86.2 g, energy 184 kJ (44 kcal), protein 1.6 g, fat 0.1 g, carbohydrate 11.1 g, fibre 2.5 g, Ca 160 mg, P 60 mg, Fe 3.8 mg, β-carotene equivalent 285 μg, thiamin 0.04 mg, riboflavin 0.06 mg, niacin 0.5 mg, ascorbic acid 14 mg. The nutritional composition of the seed per 100 g edible portion is: water 8.2 g, energy 1721 kJ (411 kcal), protein 19.6 g, fat 16.0 g, carbohydrate 51.3 g, dietary fibre 11.0 g, Ca 356 mg, P 462 mg, Fe 4.2 mg, thiamin 0.1 mg, riboflavin 0.15 mg, niacin 1.4 mg, ascorbic acid trace (Leung, W.-T.W., Busson, F. & Jardin, C., 1968).

The dried red calyces contain organic acids, sugars and anthocyanin pigment. They are high in citric, malic and ascorbic acids. Roselle seed oil has properties similar to cotton seed oil and contains linoleic, oleic, palmitic and stearic acids as major fatty acids. A number of exceptional fatty acids, e.g. epoxy oleic acid and the cyclopropene acids sterculic acid and malvalic acid, have been reported in the seed oil. Seed proteins are mostly globulins, highly soluble at acidic and alkaline pH levels.

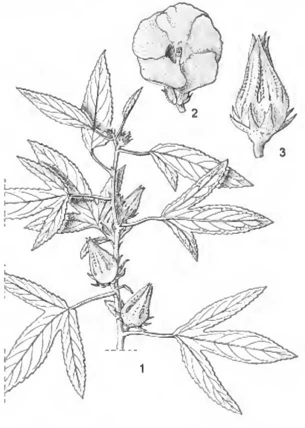
Roselle has antispasmodic, anthelminthic and bactericidal properties. The antihypertensive and cardioprotective effects of tea made from roselle calyces have been demonstrated in various animal tests, and also in a few clinical tests. The phenolic compound protocatechuic acid isolated from roselle flowers showed antioxidant, antitumour and hepatoprotective activities. Roselle extracts also showed antipyretic and anodyne properties in tests with mice. The seed oil exhibits antibacterial and antifungal activities.

Roselle produces a bast fibre similar to jute (*Corchorus capsularis* L. and *Corchorus olitorius* L.), except that it is whiter and somewhat coarser. The raw retted and dried fibre makes up about 5% and the dry wood 18% of the freshly harvested and defoliated green stems. The commercial fibre has a length of up to 2.1 m. The bast fibre cells are (1.2–)1.9–3.1(–6.3) mm long and (10–)12–25(–44) μm wide, with maximum length and width in the middle portion of the stem. Lumen width and cell wall

thickness vary from 3–15 μm and (4–)8–15 μm, respectively. Most fibre cells have tapering rounded ends. The wood consists of fibre cells 0.5–1.0 mm long and about 24–26(–32) μm wide, with a lumen width of 9 μm and a cell wall thickness of 3–7 μm. The bast fibres contain about 32% α-cellulose, 10–15% lignin and 1% ash.

Adulterations and substitutes Leaves of other *Hibiscus* spp., e.g. kenaf (*Hibiscus cannabinus* L.) and false roselle (*Hibiscus acetosella* Welw. ex Hiern) can be used as substitutes for roselle. They are sometimes even sold together.

Description Large annual herb up to 4.5 m tall; stem glabrous to sparsely pubescent, sometimes sparsely prickly, green or reddish. Leaves alternate, simple; stipules narrowly lanceolate to linear, up to 1.5 cm long; petiole 0.5–12 cm long; blade shallowly to deeply palmately 3–5(–7)-lobed, sometimes undivided, up to 15 cm × 15 cm, margin toothed, glabrous or sparsely pubescent, sometimes with a few prickles on midrib, palmately veined, with a distinct nectary at base of midrib. Flowers solitary in leaf axils, bisexual, regular, 5-merous; pedicel up to 2 cm long, articulate; epicalyx segments 8–12, united at base, subulate to triangular, free part 0.5–2 cm long; calyx campanulate, up to 5.5 cm long, becoming fleshy in fruit, lobes nearly glabrous to hispid hairy, with a nectary outside; petals free, obovate, up to 5 cm × 3.5 cm, pale yellow or pale pink, often with dark red-purple centre; stamens numerous, united into a column up to 2 cm long, pink; ovary superior, 5-celled, style with 5 branches. Fruit an ovoid capsule up to 2.5 cm long, almost glabrous to appressed-pubescent, enclosed by the calyx, many-seeded. Seeds reniform, up to 7 mm long, dark brown. Seedling with epigeal germination; cotyledons rounded, up to 2.5 cm × 3 cm, leafy.



Hibiscus sabdariffa – 1, flowering and fruiting shoot; 2, flower; 3, fruit enclosed by calyx. Source: PROSEA

Other botanical information *Hibiscus* comprises 200–300 species, mainly in the tropics and subtropics; many of them grown as ornamentals. The estimated number of species varies because opinions differ about inclusion of several related groups of species in the genus. *Hibiscus sabdariffa* belongs to section *Furcaria*, a group of about 100 species which have in common a pergamentaceous calyx (rarely fleshy) with 10 strongly prominent veins, 5 running to the apices of the segments and bearing a nectary, and 5 running to the sinuses. Other species belonging to this section and used as a vegetable are *Hibiscus acetosella* Welw. ex Hiern, *Hibiscus asper* Hook.f., *Hibiscus cannabinus* L., *Hibiscus diversifolius* Jacq., *Hibiscus mechowii* Garcke, *Hibiscus noldeae* Baker f., *Hibiscus rostellatus* Guill. & Perr. and *Hibiscus surattensis* L.

Two main types of cultivated *Hibiscus sabdariffa* are distinguished, originally described as botanical varieties: var. *sabdariffa* with a bushy, strongly branching habit and glabrescent calyx, accrescent and becoming fleshy in fruit; and var. *altissima* Wester with taller, usually unbranched habit and often hispid hairy calyx, hardly accrescent and not fleshy in fruit. The latter is grown for its fibre, and not common in Africa. These types can best be regarded as cultivar-groups.

Hundreds of cultivars grown as vegetable or for their calyces exist. In some of these anthocyanins are present, resulting in reddish stems, leaves and calyces, and pinkish petals, whereas in others anthocyanins are absent, and these have green stems and leaves, pale green calyces and pale yellow petals.

Growth and development The vegetative growth period lasts from 4 months to 6 months. Plant height 30 days after emergence of the seedlings is about 30 cm. Leaf harvest may

start 6–8 weeks after sowing; it stimulates branching and subsequently increases leaf production. Flowering begins when daylength decreases, at the earliest 2 months after sowing, and at the latest 7 months. The flowers are ususally self-pollinating. Two or three months after pollination fruits may begin to ripen.

Ecology Roselle has temperature requirements ranging between 18°C and 35°C. Plant growth stops at 14°C, with death occurring after 15 days. At 10°C, death occurs after only 2–3 days. Flower and calyx production is reduced at temperatures below 17°C. Cotyledons cannot withstand temperatures below 10°C for more than 2–3 hours.

Roselle is a photoperiod sensitive plant that flowers best when the daylength is shorter than 12 hours. It requires 13 hours/day light during vegetative growth to prevent premature flowering. Having a deep root system, roselle requires adequate soil depth and is rather drought resistant. The crop can grow in a wide range of soil types, the best being retentive, friable loams. Roselle thrives in areas receiving 800–1600 mm of continuous annual rainfall, and requires a minimum of 100–150 mm/month during vegetative growth, or 300–400 mm distributed over a period of 3–4 months. Dry periods during the final months of growth promote good calyx production, while excess precipitation or humidity can lower the quality of the calyces. Roselle plants with anthocyanin pigmentation are able to withstand the harsh Sahelian environment better than plants with a yellow-green colour.

Apparently wild types of *Hibiscus sabdariffa* are found in savanna grassland and open woodland.

Propagation and planting Roselle is grown both as a rainfed field crop and as an irrigated garden vegetable. As leafy vegetable, seeds are either broadcast or dibbled with 3–5 seeds/hole, 2–3 cm deep, at an average spacing of 40–60 cm in rows and 60–90 cm between rows. The 1000-seed weight is (15–)25–28 g. For calyx production, the spacing should be wider, up to 100 cm apart. In Senegal vegetable farmers use 15–25 kg seed per ha for calyx production, whereas research recommends only 4–8 kg. Some growers sow in a shaded nursery, and transplant into the field after about 4 weeks. For fibre production, seeds are drilled more closely, at 15 cm × 20 cm or 10 cm × 30 cm. Because roselle is deep rooting, deep ploughing is recommended for heavier soils. In sandy soils shallow ploughing is common.

Rainfed roselle crops are sown at the beginning of the rainy season. In the Sahel region year-round planting is possible with irrigation. Roselle is often intercropped with other crops such as pearl millet, sorghum, groundnut, sweet potato, yam or cowpea, and spontaneous roselle plants are often allowed to grow amongst other crops. Many farmers plant roselle along field boundaries or to delineate subplots within a field. In West Africa roselle is also grown as part of a parkland agroforestry system, in conjunction with e.g. apple-ring acacia (*Faidherbia albida* (Delile) A.Chev.), baobab (*Adansonia digitata* L.), African locust bean (*Parkia biglobosa* (Jacq.) R.Br. ex G.Don, shea butter tree (*Vitellaria paradoxa* C.F.Gaertn.) and jujube (*Zizyphus mauritania* Lam.).

Management Roselle grown in home gardens as a leafy vegetable or for leaves and calyces is cultivated under irrigation, mostly done manually with watering cans. It is given normal garden management. When grown as a field crop for calyces little care is generally given unless grown in intercropping. It then benefits from the care given to the main crop. Roselle responds well to fertilizers. In Egypt ammonium sulphate has been reported to result in higher yields than calcium nitrate or urea. Calyx production is greater when plants are fertilized at thinning (20–30 days after planting) than when the applications are split and given during the vegetative stage and at flowering. However, chemical fertilizers are rarely applied in tropical Africa as they are too costly under the uncertain climatic conditions where roselle is grown. A few t per ha of dry organic manure is sometimes applied. Smallholder farmers regard roselle as a low-input, low-labour crop. Weeding is rarely practised, but if done it results in higher calyx yields. Better calyx yields were observed when roselle is intercropped, particularly with a legume planted two weeks after establishment of the roselle crop.

In Thailand and India roselle for fibre is grown as a rainfed crop. A single round of weeding and thinning is usually performed 20–30 days after planting. The recommended fertilizer dose is 15 kg N, 15 kg P and 15 kg K per ha given after weeding.

Diseases and pests Roselle is susceptible to most diseases affecting cotton, and root and stem rot caused by several *Phytophthora* spp. lead to plant losses. *Phytophthora nicotianae* var. *parasitica* causes stem burn (also called

collar rot or stem canker), causing purplish black discoloration encircling the stem 30 cm above the ground and sudden wilting of the plant. Resistance has been found in fibre-type roselle cultivars. Unlike its close relative kenaf, roselle is susceptible to infection by *Coniella musaiaensis* var. *hibisci*. Plant and calyx senescence due to this pathogen have been observed in Central Africa, Nigeria, the Caribbean region and India. Irregular, pale brown lesions appear on lower leaves increasing in size, bleaching the leaf surface and ultimately resulting in necrosis of tissue. Brown stem lesions may also develop. Leaf spot caused by *Cercospora hibisci* is also common. Roselle types with green leaves are susceptible to powdery mildew (*Oidium abelmoschi*), types with red leaves are partially resistant. A virus disease is reported from Nigeria, causing hard cracking leaves. Roselle is rather resistant to root-knot nematodes (*Meloidogyne* spp.), but not to free-living nematodes (*Heterodera* spp.).
Pressure from insect pests is high. Cotton bollworm larvae (*Earias biplaga*, *Eaias insulana*) are very damaging as they bore into the unripe fruits. The larvae of flea beetles (*Podagrica* spp.) feed on the roots and the adults damage leaves and growing points. The cotton stainer (*Dysdercus superstitiosus*) sucks on the calyces, causing brown spots. Infestation by spiral borers (*Agrilus acutus*) can lead to galls on the stems, approximately 5 cm in length and leading to some reduction in nutrient uptake. However, research in Bangladesh has demonstrated roselle to be much more resistant to infestation than kenaf. Other pests are cutworm, mealy bugs, leaf hoppers and snails. Attacks by insect pests can be reduced by beneficial predators, e.g. it was observed that jassids (*Amrasca biguttula*) were predated by 8 species of spiders. Similarly, *Hibiscus sabdariffa* has helped reduce pest populations in intercropped systems, e.g. infestation of bean (*Phaseolus vulgaris* L.) by several white fly species was reduced by intercropping with roselle, due to increased hyperparasite diversity.

Harvesting The first harvest comprises seedlings collected during thinning. When the plants are 6–8 weeks old, branches of about 50 cm long are picked 2 or 3 times during the period of vegetative growth. Calyces are harvested manually 2–3 weeks after flowering, usually 4–6 months after sowing, before the fruit has dried and dehisced. Regular picking prolongs flowering. The calyces are dried in the shade. When harvested for fibre, stems are cut before flowering, 4–5 months after planting. Fibre quality declines rapidly after the start of flowering.

Yield For leafy branches yields of up to 20 t/ha from three cuttings have been reported. Fresh calyx yields range from 4–6.5 t/ha, or about 800–1200 kg/ha when dried to 12% moisture content. In Asia fresh calyx yields of up to 15 t/ha have been reported. A single roselle plant may yield as many as 250 calyces, or 1–1.5 kg fresh weight. In Africa average yields are much lower and variable because of environmental conditions and extensive management. Sudan reports an average yield of dry calyces of 93 kg/ha. In Senegal maximum production of calyx on a dry weight basis is 500 kg/ha.
Average fibre yields from roselle are 1.5–2.5 t/ha, depending on cultivar and management. India reported an average yield of 1.9 t/ha for 1997–2001. Reported seed yields range from 200–1500 kg/ha.

Handling after harvest As a leafy vegetable roselle shoots are sold in bunches with a length of up to 50 cm. Thinned seedlings are less perishable than shoots; as they are sold with their roots attached they can be kept fresh by placing the roots in water.
In most areas in Africa roselle calyces are air dried prior to marketing. Drying in the sun can lead to reduced quality. Adequate ventilation is important. Plastic sheets are placed on the ground to avoid contamination with soil, which also strongly reduces the value. Drying by artificial heating is capital-intensive and rare in sub-Saharan Africa. Temperatures must remain below 43°C.
Dried calyces are gathered and sold in bulk or in individual sachets throughout West Africa. In Senegal dried calyces are rolled into 80 kg balls for export. Roselle exported to the United States and Germany must meet strict standards concerning moisture content (maximum 12%), acidity, residues and contaminations.
To make roselle syrup, dried calyces are boiled at a ratio of 1 part dried roselle to 4–5 parts water. Because of its very tart taste, large amounts of sugar are added. The mixture is boiled down for several hours. Before use the syrup is watered down to make 'da bilenni'. A study estimated that one person could produce about 300 l juice per day from 4 kg calyces.
For the production of fibre, harvested stems are soaked in water for two weeks, and then stripped of bark. Stems are then beaten to separate the fibres, which are washed, dried,

and sorted into one of three levels of quality, based on length, colour, stiffness and purity. In some parts of Africa roselle seeds are ground into meal for addition to cereals, or seeds are roasted and boiled as a coffee substitute. Oil is extracted by parching the seeds, soaking in water made alkaline with ashes, and pounding them. The residue is sometimes eaten in soup or blended with bean meal to make fried snacks.

Genetic resources Local cultivars of roselle are common throughout semi-arid Africa. Although many smallholder farmers separate seeds by cultivar, stocks are generally heterogeneous. Roselle planted by traditional farmers in Sudan is usually of several different types and cultivars. Around 50 accessions from the local genetic resources in Sudan are preserved in the genebank of the Plant Genetic Resources Unit of the Agricultural Research Corporation, Wad Medani, Sudan. Characterization of some of these accessions revealed variation in stem colour, leaf shape and calyx shape, colour and size. A practical classification used in Sudan for the many beverage strains is on the basis of calyx characteristics. The calyx lobes may be thick, curved outwards and easy to peel; or long, bending inwards, enclosing the fruit and easy to peel; or thin, tightly enclosing the fruit and difficult to peel; or bell shaped with well-developed epicalyx. In Senegal farmers distinguish between 7 'bissap' types, 3 green types and 4 red ones. The distinctive characters used to identify the 'bissap' types include colour, size and shape of leaves and fruits. Seeds of 'bissap' germplasm in Senegal are stored at the Seed Production Unit, Horticultural Development Centre (CDH), Dakar. Other germplasm collections of *Hibiscus sabdariffa* are held at Jute Research Institute, Dhaka, Bangladesh (320 accessions), USDA Southern Regional Plant Introduction Station, Griffin GA, United States (95 accessions), Central Research Institute for Jute and Allied Fibres, Barrackpore, India (75 accessions) and National Horticultural Research Instutute, Ibadan, Nigeria (11 accessions).

Breeding Roselle breeding has hitherto received little attention hitherto. The Sudanese cultivar 'El Rahad' is considered superior in quality for calyx production. Breeding objectives of roselle in Sudan include purification of local cultivars and selection for better yield and calyx quality. In Senegal the objectives of the breeding programme include the improvement of leaf yield of green cultivars, and the improvement of yield and taste of cultivars suited for calyx production. Seed company Technisem markets seed of cultivar 'Bissap Koor Rouge', suitable for use as leafy vegetable and for calyx production, and tolerant of nematodes and heat.

Prospects Roselle is an underutilized multipurpose crop providing farmers with food and cash income when other vegetables have become scarce. Processing generates additional family income, from which women benefit in particular. Use of roselle as a vegetable or as a beverage should be promoted through research to improve cultivars, husbandry and post-harvest technologies. Applying rigorous quality standards for grading, processing and packaging will boost competitiveness in the international market. Demand for roselle fibre is likely to increase as a result of the rising interest in natural, biodegradable fibres.

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Sources of illustration Boonkerd, T., Na Songkhla, B. & Thephuttee, W., 1993b.

Authors N.C. McClintock & I.M. El Tahir

HIBISCUS SURATTENSIS L.

Protologue Sp. pl. 2: 696 (1753).
Family Malvaceae
Chromosome number $2n = 36$

Vernacular names Wild sour, shrub althea (En). Oseille indigène, oseille malabare (Fr).

Origin and geographic distribution *Hibiscus surattensis* occurs in tropical Africa and tropical Asia. It is found in most countries of

Hibiscus surattensis – wild

tropical Africa, including the Indian Ocean islands, and also in South Africa and Swaziland. It has been introduced in tropical America and is locally naturalized there.

Uses The mucilaginous leaves of *Hibiscus surattensis* are commonly used as a potherb in many areas in Africa and Asia; they are sometimes eaten raw as a salad. In Uganda, it is a popular vegetable; the leaves are boiled and added to peas or groundnuts and sesame paste and served with a staple food. It is also used to thicken sauces. In DR Congo the leaves are cooked with fish or meat. Young leaves are sometimes used as a condiment.

The bark yields a fibre, which is occasionally used as cordage. In Uganda, cooked leaves are used to coagulate the latex of *Landolphia* spp. In Guinea and DR Congo the plant is regarded as a tonic for heart and stomach. In Nigeria the leaves are used in poultices; in Gabon softened leaves are applied to boils. In Senegal the seed has been used as a remedy for eye diseases and dysentery. In Tanzania leaf sap is taken to prevent miscarriage and to treat vertigo, whereas a root decoction is used as a laxative. In South Africa the Zulu people use a lotion of the leaf and stem for the treatment of penile irritation of any sort, including venereal sores and urethritis. An infusion is also used for injecting into the urethra and vagina to treat gonorrhoea and other inflammations. An ointment made from the leaves is sometimes applied for the same purposes, whereas in Nigeria decoctions of the leaves and roots are used similarly. In DR Congo dried leaf powder is used to cure wounds. In Kenya the ash from the plant is applied to cuts, and an infusion to treat itch caused by chickenpox.

Production and international trade In many parts of tropical Africa leaves of *Hibiscus surattensis* are sold in local markets, but no statistical data on production and trade are available.

Properties. There is no information on the nutritive value of *Hibiscus surattensis* leaves, but it is probably comparable to the related *Hibiscus sabdariffa* L. The leaves of *Hibiscus surattensis* have shown a growth inhibitory effect on *Staphylococcus aureus*.

Adulterations and substitutes *Hibiscus surattensis* leaves in dishes can be replaced by the leaves of *Hibiscus acetosella* Welw. ex Hiern, *Hibiscus sabdariffa* L. or other *Hibiscus* spp., which give the same taste.

Description Prostrate or climbing annual herb; stem prickly with recurved prickles, pubescent. Leaves alternate, simple; stipules ovate, auriculate, amplexicaul, up to 1.5 cm × 1 cm; petiole 2–7(–11) cm long, prickly and pubescent; blade shallowly to deeply palmately 3–5-lobed, up to 10 cm × 10 cm, margin serrate, pubescent, prickly on veins below, palmately veined. Flowers solitary in leaf axils, bisexual,

Hibiscus surattensis – 1, leaf; 2, part of flowering twig; 3, fruit; 4, seed.
Redrawn and adapted by Achmad Satiri Nurhaman

regular, 5-merous; pedicel up to 8 cm long, articulate, prickly; epicalyx segments 8–10, bifurcate, the outer fork spatulate and c. 0.5 cm long, the inner fork linear, c. 1 cm long; calyx cup-shaped, up to 2.5 cm long, lobes prickly; petals free, obovate, up to 6 cm × 4 cm, bright yellow with red-purple base; stamens numerous, united into a column up to 2 cm long, red-purple; ovary superior, 5-celled, style with 5 branches. Fruit an ovoid to globose capsule up to 1.5 cm long, densely pubescent, many-seeded. Seeds reniform, c. 3 mm × 2 mm.

Other botanical information *Hibiscus* comprises 200–300 species, mainly in the tropics and subtropics; many of them are grown as ornamentals. The estimated number of species varies because opinions differ about inclusion of several related groups of species in the genus. *Hibiscus surattensis* belongs to section *Furcaria*, a group of about 100 species which have in common a pergamentaceous calyx (rarely fleshy) with 10 strongly prominent veins, 5 running to the apices of the segments and bearing a nectary, and 5 running to the sinuses. Other species belonging to this section and used as a vegetable are *Hibiscus acetosella* L., *Hibiscus asper* Hook.f., *Hibiscus cannabinus* L., *Hibiscus diversifolius* Jacq., *Hibiscus meeusei* Garcke, *Hibiscus noldeae* Baker f., *Hibiscus rostellatus* Guill. & Perr. and *Hibiscus sabdariffa* L.

Growth and development *Hibiscus surattensis* is an annual plant growing naturally during the rainy season. It is mainly self-pollinating.

Ecology *Hibiscus surattensis* occurs in grassland and at forest edges in lowland and at medium altitudes up to 1700 m, in regions with an average annual rainfall of 1000–1600 mm. It also occurs in marshes, abandoned fields and plantations, on waste ground near habitation, and in coastal habitats such as sand dunes. It is found on a wide variety of soil types.

Management When cultivated *Hibiscus surattensis* is propagated by seed. The main management practice is weeding. However, this species is rarely cultivated and the leaves are usually collected from the wild for use as a vegetable.

Diseases and pests *Hibiscus surattensis* is a host to pink mealybug (*Maconellicoccus hirsutus*).

Harvesting Leaves of *Hibiscus surattensis* are collected in the early flush of the rainy season.

Handling after harvest The leaves can be cooked immediately as a vegetable, or dried, pounded and kept for up to a year and used later in a similar way as the fresh leaves.

Genetic resources There are no indications that *Hibiscus surattensis* is in danger of genetic erosion, although it is reported to be locally uncommon, e.g. in Uganda. No germplasm collections are known to exist.

Prospects *Hibiscus surattensis* is an under-utilized but locally popular sturdy leafy vegetable. Genetic improvement and management practices should be studied for further domestication.

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Sources of illustration Berhaut, J., 1979; Vollesen, K., 1995b.

Authors M. Mosango

HIBISCUS TRIONUM L.

Protologue Sp. pl. 2: 697 (1753).

Family Malvaceae

Chromosome number $2n = 56$

Vernacular names Flower of an hour, bladder hibiscus, bladder weed, bladder ketmia, Venice mallow, devil's head in a bush, trailing hollyhock (En). Fleur d'une heure, ketmie d'Afrique (Fr).

Origin and geographic distribution *Hibiscus trionum* occurs throughout the Old World tropics and subtropics, and even in temperate areas. In Africa it is only absent from the Guineo-Congolian rainforest zone. In the New World it was introduced and has become naturalized.

Uses Young leaves, flowers and young shoots of *Hibiscus trionum* are eaten raw or cooked in Kenya, Zimbabwe, Australia and China. In Australia the root is considered edible although very fibrous. *Hibiscus trionum* is cultivated as an ornamental in the subtropics.

In South Africa an infusion is made of the ground shoot to clean wounds; it relieves pain and helps in drying the wound. It is also used against roundworm in Zimbabwe and South

Africa, and as a stomachic in China. In eastern Sudan dry fruits are given to camels as a laxative. In India an infusion of the flowers is used to treat itch and painful skin problems, and as a diuretic. In southern Europe the leaf is used as an expectorant and to treat warts.

Properties Cooked leaves of *Hibiscus trionum* are mucilaginous, without much flavour. The seeds contain 22–24% of oil and a small quantity of gossypol.

Botany Annual herb up to 1.5 m tall; stem with stellate hairs or hispid. Leaves alternate, simple to deeply palmately 3–5-lobed; stipules linear, up to 8 mm long; petiole 1–4.5 cm long; blade orbicular to ovate in outline, up to 7.5 cm × 9 cm, base truncate to slightly cordate, lobes pinnately incised, margin serrate or slightly sinuate, hispid on veins, palmately veined. Flowers solitary, axillary, bisexual, regular, 5-merous; pedicel up to 5.5 cm long; epicalyx segments 10–12(–13), filiform, 7–14 mm long, apex entire; calyx campanulate, up to 2.5 cm long, becoming inflated, ribs of lobes purplish with stellate hairs or hispid; petals free, obovate, up to 3.5 cm × 3 cm, white, cream or yellow with purple base; stamens numerous, united into a column up to 4 mm long; ovary superior, 5-celled, style with 5 branches, included in the staminal column. Fruit an ovoid to globose capsule up to 1.5 cm long, hispid, enclosed in calyx, many-seeded. Seeds reniform, c. 2 mm × 3 mm, dark brown.

Hibiscus comprises 200–300 species, mainly in the tropics and subtropics. Although very variable in leaf shape and size of flowers, *Hibiscus trionum* is not likely to be confused with other species of the genus in Africa. It is classified in a separate section *Trionum*, characterized by its inflated, bladderlike calyx in fruit. *Hibiscus mutabilis* L., an introduced ornamental naturalized in parts of Africa, also has an inflated calyx but is a shrub with flowers 8–10 cm in diameter, white turning red by evening. Flowers of *Hibiscus trionum* only open when the sun shines and are short-lived. Cross- and self-pollination (delayed selfing) both occur.

Ecology *Hibiscus trionum* occurs in grassland, along roadsides and as a weed of arable crops, up to 2800 m altitude. In East Africa it is common on black cotton soils. The minimum, optimum and maximum temperatures for seed germination were found to be 10°C, 30°C and 40°C respectively.

Management *Hibiscus trionum* is a host of cucumber mosaic virus (CMV), whitefly (*Bemisia tabaci*) and spiny bollworm (*Earias insulana*).

Genetic resources and breeding Several genebanks have accessions of *Hibiscus trionum*. As the species is widespread and abundant, it is not at risk of genetic erosion. Several improved ornamental cultivars have been released such as 'Simply Love' and 'SunnyDay'.

Prospects *Hibiscus trionum* will remain a minor vegetable of only local importance. The widespread medicinal use in treating skin problems warrants pharmacological research.

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Authors C.H. Bosch

HOODIA CURRORII (Hook.) Decne.

Protologue DC., Prodr. 8: 665 (1844).

Family Asclepiadaceae (APG: Apocynaceae)

Chromosome number $2n = 22$

Synonyms *Hoodia lugardii* N.E.Br. (1903), *Hoodia macrantha* Dinter (1914), *Hoodia gibbosa* Nel (1937), *Hoodia montana* Nel (1937).

Vernacular names Ghaap, hoodia cactus (En).

Origin and geographic distribution *Hoodia currorii* is found in Namibia and Angola (subsp. *currorii*), and in Botswana and southern Zimbabwe (subsp. *lugardii* (N.E.Br.) Bruyns).

Uses Stems are broken or cut off, rubbed on a stone to remove the spines, cut into strips and these strips are eaten. They have a peculiar pervasively spreading sweet taste which is remarkably persistent and is said to quench thirst and hunger for extended periods. They also make a tasty preserve. Young pods are much sought after for their sweetness. Stems that have swelled after recent rains are preferred. Sometimes they are taken home to be soaked in water before being eaten. It is also said that after eating, an interesting liquorice-like aftertaste remains which gives tobacco smoke a particularly pleasant taste.

For thousands of years, African tribesmen in South Africa, Botswana, Namibia and Angola have eaten *Hoodia* to stave off hunger and thirst on long hunting trips. *Hoodia* has recently attracted the interest of the Western drug industry. The Council for Scientific and

Industrial Research in South Africa has identified the active principle of *Hoodia* and patented it. In 2001 they passed on their findings to a British firm, which patented the appetite-suppressing ingredient in *Hoodia*, on the basis of its potential as a slimming drug. This firm sold the rights to license the drug to a United States pharmaceutical company, which hoped to have the treatment ready in pill form within 3 years. The San, an African tribe, considered this situation to be bio-piracy because the knowledge has been taken from them without paying proper compensation. The International Intellectual Property Institute, Washington, United States was the intermediary in this matter. In 2003 an agreement was reached between the San and the pharmaceutical company: the San will receive 1.5 million US$ per year for a period of 4 years while the drug is being developed and as soon as the medicine is marketed they will receive 6% of the royalties.
Other traditional medicinal applications mentioned are to treat indigestion, hypertension, diabetes, haemorrhoids and stomachache. Most *Hoodia* species are attractive and unusual ornamentals for desert gardens.

Botany Spiny succulent shrub up to 1 m tall, with many erect to spreading, branching stems; stem cylindrical, 4–8 cm in diameter, grey-brown-green, with 11–24 vertical ribs consisting of prominent obtuse tubercles each one tipped with a sharp spine 6–10 mm long. Flowers arising in groups of 1–4 near the apex of the stem, opening successively, bisexual, regular, 5-merous; pedicel 1–6 cm long; sepals ovate-lanceolate, 4–8 mm × 3 mm; corolla saucer-shaped, consisting of a short pentagonal tube 3–6 mm × 6–9 mm, and a subcircular to clearly lobed limb 4–18 cm in diameter, outside pale red and glabrous, inside deep red or yellowish-pink and covered with pink to purple hairs 3–4 mm long, lobes broadly ovate, ending in a narrow point up to 2 cm long; corona deep red-purple or red-brown, outer corona forming a cup with bifid lobes, inner corona with linear lobes, incumbent on the backs of the anthers and mostly exceeding them to meet in the centre. Fruit a pair of fusiform, horn-like follicles, each follicle 15–22 cm long, glabrous, pink to green, 100–250-seeded. Seeds with a tuft of straight, simple hairs (coma) 15–25 mm long.
Hoodia currorii is very variable and has been divided into 2 subspecies: subsp. *currorii* (corolla 5–17 cm in diameter, pedicel longer than 12 mm, occurring in Angola and Namibia) and subsp. *lugardii* (N.E.Br.) Bruyns (corolla 4–7.5 cm in diameter, pedicel shorter than 7 mm, occurring in Botswana and Zimbabwe).
Hoodia comprises 13 species, and the related *Lavrania* comprises 5 species. *Lavrania* differs from *Hoodia* by the tubercles on the stems: in *Hoodia* they are tipped with a spine 3–12 mm long which is initially green, drying out to grey-brown and base not depressed into apex of tubercle; in *Lavrania* the tubercles are tipped with a small conical persistent leaf less than 1 mm long, remaining grey-green, not drying out, usually sunken into the apex of the tubercle.
The stems of many other *Hoodia* species are eaten, although there are differences in flavour (more or less bitter). They form a convenient emergency food and moisture source in harsh arid environments. Other recorded edible species are: *Hoodia alstonii* (N.E.Br.) Plowes (Namibia, South Africa), *Hoodia flava* (N.E.Br.) Plowes (Namibia, South Africa), *Hoodia gordonii* (Masson) Sweet ex Decne. (Namibia, South Africa), *Hoodia officinalis* (N.E.Br.) Plowes (Namibia, South Africa) and *Hoodia pilifera* (L.f.) Plowes (South Africa). They are all commonly known as 'ghaap'. The young pods of all species are liked for their sweetness. *Lavrania* species are never eaten; they have an extremely strong, bitter taste and are widely (probably falsely) considered poisonous.
The primary stem of seedlings of *Hoodia currorii* grows vertically up from between the cotyledons and after it has reached some size, axillary buds near the base give rise to secondary shoots. After a few years, when the plant is about 20 cm tall, flowering starts near the apex of the main stem and branches. After flowering, vegetative growth continues and in subsequent years new flushes of flowers appear in the higher portion of the stem. Most *Hoodia* flowers have a foetid, excrement-like odour; they produce nectar and pollination is mostly effected by flies.

Ecology In Angola *Hoodia currorii* subsp. *currorii* is restricted to the very arid parts of the coastal Namib Desert; in Namibia it also occurs in this arid zone and also eastward (up to 250 km from the coast), e.g. in dry, short forest and in dry *Acacia* scrub vegetation. Subsp. *lugardii* is found further east than any other *Hoodia* species, growing on calcareous soil, often forming a shrub around the base of *Acacia tortilis* (Forssk.) Hayne or *Colophospermum mopane* (Benth.) J.Léonard.

Management Almost all *Hoodia* species can be propagated by seed and by cuttings taken

from the base of a branch. Cultivation is not easy because of the need for hot and dry conditions. Cultivated plants usually die because of a too moist growing medium and a lack of fresh air. A recommended medium is 1 part clay, 3 parts humus-rich soil and 4 parts rough sand or gravel.

Genetic resources and breeding As a consequence of the general degradation of vast parts of southern Africa through overgrazing by sheep and goats, *Hoodia* species have practically disappeared in some areas where they were formerly abundant. All species are now protected by CITES regulations and some species are in danger of extinction.

Prospects *Hoodia currorii* and other *Hoodia* species cannot be recommended as a vegetable from the wild because of the danger of extinction. The nutritive value should be investigated further and commercial cultivation possibilities need more research. Possibly, the ornamental and medicinal values far exceed other commercial prospects, making large-scale commercial cultivation an interesting option. As a suppressant of appetite and thirst, the active principle of *Hoodia* seems to have a bright future.

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Other references Albers, F. & Austmann, M., 1987; Noltee, F. & de Graaf, A., 1983; van Wyk, B.-E., van Oudtshoorn, B. & Gericke, N., 1997; Watt, J.M. & Breyer-Brandwijk, M.G., 1962.

Authors P.C.M. Jansen

IMPATIENS IRVINGII Hook.f. ex Oliv.

Protologue Fl. trop. Afr. 1: 300 (1868).

Family Balsaminaceae

Chromosome number $2n = 14$

Vernacular names Impatience d'Irving (Fr).

Origin and geographic distribution *Impatiens irvingii* occurs from Guinea east to Gabon, the Central African Republic, DR Congo, south-western Sudan, Rwanda and southern and western Tanzania, and south to Angola, Malawi and northern Zambia.

Uses The leaves of *Impatiens irvingii* are eaten as a vegetable in Liberia. The plant is used in the Democratic Republic of Congo, Gabon and Sudan to produce a high quality vegetable salt. The young leaves are used in Côte d'Ivoire as a treatment for schistosomiasis. It is occasionally grown as an ornamental pot plant.

Properties The flavonoids procyanidin and prodelphidin have been isolated from the stems, sepals and petals of *Impatiens irvingii*.

Botany Sprawling or more or less erect perennial herb; stem succulent, up to 1.5 m long. Leaves arranged spirally, simple; petiole up to 1.5 cm long; blade lanceolate to oblong-elliptical, up to 18 cm × 4.5 cm, base cuneate, apex acute, subacute or acuminate, margin serrate-denticulate. Flowers axillary, solitary or in fascicles of 2–3, bisexual, zygomorphic, 5-merous, rose violet or pale purple; lower sepal spurred, c. 5 cm long; lateral petals paired, dorsal petal sub-orbicular or slightly obovate, up to 15 mm × 18 mm. Fruit a fleshy, explosive, 5-valved, fusiform capsule 14–18 mm × 4–6 mm.

Impatiens irvingii is extremely variable, especially in pubescence, leaf shape and flower size. In its natural range it flowers throughout the year. In Nigeria aquatic snail species were found to be strongly associated with *Impatiens irvingii*, which is helpful in monitoring and controlling snails that host schistosoma.

Ecology *Impatiens irvingii* grows in moist localities in rain forest, swamps or along watercourses, sometimes in shallow water. It is restricted to altitudes of 400–900 m.

Genetic resources and breeding As *Impatiens irvingii* is widely distributed there is no threat of extinction. There are no documented accessions in germplasm collections but it is grown in botanical gardens and by amateur gardeners in many parts of the world.

Prospects It is not likely that *Impatiens irvingii* will find wider acceptance as a vegetable crop. The obvious lack of interest from pharmacologists so far is surprising. Research into the role it may play in schistosomiasis control may prove worthwhile.

Major references Burkill, H.M., 1985; Grey-Wilson, C., 1980; Ofoezie, I.E., 1999; Rosna Mat Taha, 2001.

Other references Hegnauer, R., 1989.

Authors C.H. Bosch

IMPATIENS NIAMNIAMENSIS Gilg

Protologue Bot. Jahrb. 43: 104 (1909).

Family Balsaminaceae

Chromosome number $2n = 32$

Vernacular names Parrot plant, Congo's cockatoo, red cockies beak (En). Impatience du Zaïre, impatience bec-de-perroquet (Fr).

Origin and geographic distribution *Impatiens niamniamensis* occurs from Cameroon east to the Central African Republic, southern

Sudan, south-western Kenya and north-western Tanzania, and south to Angola.

Uses In DR Congo the leaves of *Impatiens niamniamensis* are eaten as a vegetable and are used to produce a vegetable salt. The leaves are eaten in Congo as a cure for heart troubles and illnesses caused by evil spirits. In both countries mentioned, the leaves are used to make poultices and dressings to treat wounds and sores and to alleviate all kinds of painful conditions. *Impatiens niamniamensis* is widely grown in Africa as an ornamental garden or potplant.

Properties The flavonoids procyanidin and prodelphidin have been isolated from the sepals and petals of *Impatiens niamniamensis*.

Botany Erect perennial herb up to 1 m tall, sometimes epiphytic; stem succulent, becoming woody below, little branched. Leaves arranged spirally, simple; petiole 1–10 cm long; blade broadly ovate, ovate-oblong or elliptical, up to 22 cm × 9.5 cm, base cuneate, apex sub-obtuse, acute or shortly acuminate, margin crenate. Flowers axillary, in 2–6-flowered fascicles, bisexual, zygomorphic, 5-merous; lower sepal spurred, c. 5 cm long; lateral petals paired, dorsal petal cucculate, up to 10 mm × 6 mm. Fruit a fleshy, explosive, 5-valved, fusiform capsule 14–16 mm × 5–7 mm.

Impatiens niamniamensis is variable in leaf size, leaf shape, flower size and flower colour. In its natural range it flowers throughout the year.

Impatiens macroptera Hook.f. has the same uses in Congo as *Impatiens niamniamensis*. It is restricted in range (Nigeria to Gabon and Congo), altitude (600–1350 m) and ecology (humid, shaded rainforest). It is a perennial herb, up to 50 cm tall, sometimes epiphytic, with rose-pink or rose-violet flowers.

Ecology *Impatiens niamniamensis* grows in moist, densely shaded areas in bushland, swampy and riverine forests at altitudes of 350–2400 m. Frost is not tolerated.

Management *Impatiens niamniamensis* is widely cultivated as an ornamental garden or potplant. In cultivation it rarely sets seed and therefore propagation is by cuttings. Several cultivars, differing in flower colour, are recognized in the United States.

Genetic resources and breeding In view of its wide distribution there is no threat of genetic erosion or extinction. There are no known collections in scientific institutions but *Impatiens niamniamensis* is widely distributed among professional and amateur gardeners.

Prospects As an ornamental *Impatiens niamniamensis* has a bright future in tropical and subtropical areas. Research is needed to evaluate the traditional uses as a vegetable and medicinal plant.

Major references Burkill, H.M., 1985; Grey-Wilson, C., 1980; Rosna Mat Taha, 2001.

Other references Hegnauer, R., 1989.

Authors C.H. Bosch

IPOMOEA AQUATICA Forssk.

Protologue Fl. aegypt.-arab.: 44 (1775).

Family Convolvulaceae

Chromosome number $2n = 30$

Synonyms *Ipomoea reptans* Poir. (1814).

Vernacular names Kangkong, kangkung, water convolvulus, water spinach, swamp spinach, swamp morning glory (En). Kangkong, liseron d'eau, patate aquatique (Fr). Cancon, batata aquática (Po). Mriba wa ziwa (Sw).

Origin and geographic distribution *Ipomoea aquatica* is widespread as a swamp weed in all tropical and many subtropical lowland areas. It is a declared aquatic or terrestrial noxious weed in the south-eastern United States. It occurs in nearly all countries of tropical Africa, from Mauritania and Senegal, east to Eritrea and Somalia, and south to South Africa, and also in the Indian Ocean islands. It is a popular cultivated vegetable in South-East Asia and southern China, but is rare in India. It is known as a leafy vegetable in tropical America, where people of Asian origin cultivate it. It is grown on a small scale under protected cultivation in France, the United Kingdom and

Ipomoea aquatica – wild

the Netherlands for Vietnamese, Thai and Indonesian clients. In tropical Africa it is reported as a collected wild vegetable in Benin, DR Congo, Kenya and Tanzania. Asian cultivars are occasionally grown on a small scale for the Asian clientele near big cities. Kangkong can be found in market gardens, e.g. in Côte d'Ivoire and Nigeria.

Uses Young shoots and leaves of kangkong are collected for use as a leafy vegetable. Often the whole above-ground plant part of cultivated kangkong, including the tender hollow stems, is consumed. Kangkong can be stir-fried, steamed, boiled for a few minutes or lightly fried in oil and eaten in various dishes. It is often mixed with hot peppers and garlic, and prepared with meat or fish. In Asia the leaves are sometimes separated from the stems, and the stems are cooked a bit longer. In Africa only the leaves of wild plants are consumed, the stems are removed. The roots are occasionally eaten. Wild kangkong is often collected as fodder for cattle and pigs.

In Indonesia, kangkong is traditionally given at dinner to young children to make them quiet and help them sleep well. In Asia it is used in traditional medicine. The sap is used as an emetic, purgative and sedative, and flower buds are applied to ringworm. In Sri Lanka kangkong is used to treat diabetes mellitus.

Production and international trade In South-East Asia and China, many thousands hectares of kangkong are commercially produced. Thailand and some Caribbean countries export kangkong during the winter months to Europe. There are no production or yield data, and there is no international trade from Africa.

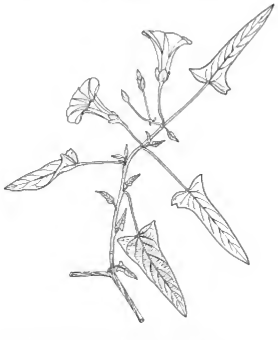
Properties The nutritional composition of raw kangkong per 100 g edible portion is: water 92.5 g, energy 80 kJ (19 kcal), protein 2.6 g, fat 0.2 g, carbohydrate 3.1 g, dietary fibre 2.1 g, Ca 77 mg, Mg 71 mg, P 39 mg, Fe 1.7 mg, Zn 0.2 mg, vitamin A 6300 IU, thiamin 0.03 mg, riboflavin 0.10 mg, niacin 0.90 mg, folate 57 µg, ascorbic acid 55 mg (USDA, 2002). The nutritional value of leaf-blades is higher than that of petioles and stems; unfortunately, sources do not state whether stems and leaves or leaves only were analysed. Accumulation of heavy metals in kangkong has been reported for Asia because the plants often grow in polluted water.

Kangkong showed oral hypoglycaemic activity in tests with diabetic humans and rats; it was shown that an aqueous leaf extract can be as effective as tolbutamide in reducing blood glucose levels.

Description Annual or perennial herb with smooth, succulent, hollow stems rooting at the nodes. Leaves alternate, simple; stipules absent; petiole 2–25 cm long; blade ovate or triangular to lanceolate or linear, 2.5–15(–25) cm × 0.5–10 cm, truncate to cordate or hastate at base, entire or coarsely toothed. Inflorescence an axillary 1–7-flowered cyme; peduncle up to 14 cm long. Flowers bisexual, regular, 5-merous; sepals free, ovate, up to 12 mm long; corolla funnel-shaped, 4–10 cm long with a narrow tube and limb c. 5 cm wide, purple, pink or white, often with purple centre; stamens inserted near base of corolla tube, unequal, included; ovary superior, 2-celled, style slender, included, stigmas 2, globular. Fruit a globose to ovoid capsule c. 1 cm in diameter, smooth, brown, enclosed by the sepals, 2–4-seeded. Seeds angular to rounded, c. 4 mm long, densely pubescent, black or pale to dark brown. Seedling with epigeal germination; cotyledons horseshoe-shaped.

Other botanical information *Ipomoea* comprises about 500 species and occurs mainly in the tropics.

Two types of cultivated kangkong are distinguished in South-East Asia. The traditional one is close to the wild type and has mostly purple flowers. It is propagated by cuttings. It has tough stems and is always harvested by ratooning. This type is being gradually replaced by white-flowering seed-propagated



Ipomoea aquatica – flowering shoot.
Source: PROSEA

kangkong, usually grown for once-over harvest, but some strongly branching cultivars are also used for ratooning. Many cultivars of the latter type have been selected, e.g. with big or small leaves, pale or dark green stems and leaves, more or less branching, fast emergence and growth, and improved keeping quality or tenderness.

In Africa, leaves of wild *Ipomoea eriocarpa* R.Br. and *Ipomoea obscura* (L.) Ker Gawl. are used as a vegetable in a similar way. Leaves of sweet potato (*Ipomoea batatas* (L.) Lam.) are a popular vegetable in many places, but their taste and tenderness do not match those of kangkong.

Growth and development Germination rates of local kangkong cultivars are often low (<60%) because of hard-seededness induced by long storage. Reliable seed companies supply improved cultivars with a high (>80%) germination percentage. Below 25°C kangkong seeds do not germinate well. Plants start developing lateral branches from cotyledonary buds 2–3 weeks after sowing. Thereafter the main axis and both laterals each produce about one leaf every 2–3 days. Cultivars selected for once-over harvest or uprooting have retarded branching or almost no branching. Ratooning of vegetatively propagated plants or wild plants can start about one month after plant establishment. Once-over harvest of direct sown plants takes place 21–30 days after sowing. After 2–5 months, kangkong starts flowering but meanwhile continues to form new leaves and branches. Kangkong is a quantitative short-day plant, early flowering being induced by short days (<12 hours). Flowering is also stimulated by drought. Kangkong is mainly self-pollinated (60–65%), but cross-pollination by bees and butterflies does occur.

Ecology Wild kangkong is found floating on water or rooting at the stem nodes in marshy or wet soil, often on river banks and as a weed in rice and other crops on wet soils. It occurs from sea-level up to 1500 m altitude. Cultivated kangkong produces optimum yields in the lowland tropics under high temperatures, full sunshine and abundant water. It is rarely grown above 500 m altitude because at temperatures below 25°C the growth rate is too slow to make it an economic crop. At higher latitudes it is grown as a summer vegetable. Kangkong is adapted to a wide range of soil conditions, but fertile soils with a high level of organic matter are preferred. The optimum pH is 5.3–6.0.

Propagation and planting Kangkong can be grown as an upland crop or in wet cultivation. Cultivation of upland kangkong is most advanced with market growers in South-East Asia and is also applied for market production in Africa, where the seed is imported from Asian seed companies. The 1000-seed weight is 50–60 g. Seed is either broadcast or sown in rows. The seed may be soaked for 12–24 hours in water before sowing. The seed rate is high, 60–100 g per 10 m^2 bed (60–100 kg/ha). If necessary, soils are limed before sowing (2500 kg/ha). Final plant densities may range from 0.3–1.7 million plants/ha. A quick and uniform emergence is an important objective of farmers.

Wet or paddy-field cultivation is still much practised in South-East Asia, but is declining because upland kangkong is more productive and has a better market quality. Planting is usually direct by cuttings, but in some places transplanting 6-week-old seedlings raised on nursery beds is used. Cuttings are planted 3–5 cm deep into the mud. Planting densities vary widely from 0.2–1.5 million cuttings per ha. Locally, floating kangkong without root contact with the soil is grown on a commercial scale in ponds and rivers, in integrated systems with fish, pigs and chicken. Cuttings are anchored to a bamboo frame floating in the water and forming a kind of bed.

Management In upland cultivation weeding is seldom needed, except when germination is slow. Daily watering with ample water is necessary. Although kangkong can do well under conditions of moderate soil fertility, it responds well to N fertilizer and the mineral uptake is high. A general fertilizer recommendation includes manure applied before sowing at a rate of up to 30 t/ha, or 10 t/ha supplemented with N 50 kg/ha , P 30 kg/ha and K 40 kg/ha. This is followed by topdressing at three 10-day intervals with N at a rate of 30, 8 and 8 kg/ha, P at 4, 4 and 0 kg/ha and K at 12, 6 and 0 kg/ha. In case of ratooning, which is common in home gardens, additional top dressing is recommended after each cutting. Application of large amounts of nitrogen fertilizer increases yield and leaf/stem ratio, but also the nitrate content, whereas the dry matter content decreases.

In wet cultivation the water level is raised in accordance with the development of the crop, reaching a depth of 15–20 cm. Young plants cannot withstand flooding. Fertilizer application is similar to upland cultivation, also with a top dressing after each cutting. Cultivation is terminated in the event of flowering or serious losses due to diseases, pests or weeds.

Diseases and pests White rust (*Albugo ipomoeae-panduratae*, often referred to as *Albugo candida*), common on sweet potato, is the most common disease of kangkong; it causes white patches which diminish the market quality. Heavy white rust infection may start as soon as two weeks after seedling emergence. Damping off of seedlings caused by *Pythium* sp. may occur, and occasionally *Cercospora* leaf spot. Owing to the short growing period, diseases and pests cause fewer problems in once-over harvested crops than in ratooned crops. Where ratooning is practised caterpillars of *Spodoptera litura* and *Diacrisia strigatula* and aphids may cause serious damage. Chemical control is a general practice, but hazardous because of residues. Root-knot nematodes (*Meloidogyne* spp.) are reported as occasionally troublesome in ratoon cropping in dry land, but not in wet soils. Upland kangkong harvested by uprooting and sown repeatedly at the same bed without any crop rotation is remarkably free of soilborne diseases, including nematodes, probably because many noxious nematodes are removed with the roots when uprooting.

Harvesting Harvesting of upland kangkong takes place from 21–30(–45) days after sowing for once-over harvest by uprooting or cutting at ground level. The damaged basal leaves are removed. The stems of the seedlings are big, tender and crisp.
In wet cultivation, harvesting by cutting young shoots starts 1–2 months after planting, and subsequently at regular intervals, or the plants are cut 5–10 cm above ground level every 4–6 weeks. The stems are thinner and more fibrous and tough than in upland kangkong.

Yield Under upland cultivation, yields per crop range from 7–30 t/ha of fresh produce, depending largely on the cultivation period. A good once-over harvested crop of 3 weeks produces 1.5–2.0 kg/m^2. The potential yield of 12 crops per year from the same bed would add up to 240 t/ha of fresh marketable produce. Under wet cultivation, yields are difficult to compare because cultivation periods differ greatly. Annual yields of 25–100 t/ha are reported in South-East Asia. For floating kangkong an annual production of 90 t/ha of fresh produce is reported for Thailand.

Handling after harvest Shoots of wetland kangkong are tied into bundles and transported to the market. Entire plants of upland kangkong are washed or wetted and sometimes wrapped in plastic to prevent wilting. For long-distance transport and supermarkets in Asia, kangkong bundles are packed in layers of 15 cm in bamboo crates with crushed ice in between. Kangkong harvested from rivers has a longer shelf life because the leaf area of the young shoots is small.

Genetic resources *Ipomoea aquatica* is extremely widespread and not in danger of genetic erosion. Germplasm collections are maintained at the Asian Vegetable Research and Development Center (AVRDC) in Taiwan and at national research institutes in South-East Asia.

Breeding Consumers have specific preferences with regard to the quality of the product, e.g. number of leaves, stem length, percentage of fibre, and taste. East-West Seed Company in Thailand selected superior cultivars from landraces for characters such as tender thick stems, rapid development, and absence of side shoots for once-over harvest. Some popular cultivars for once-over harvest are 'Yangtze' with broad leaves and grown year-round, 'Salween' with small bamboo-like leaves and suitable for the hot rainy season, and 'Liao' with bamboo-like leaves for the dry season; the strongly branching cultivar 'Chinwin' is suitable for multiple harvesting. Northern Thailand, Vietnam and southern China produce much kangkong seed, usually mechanically harvested, with yields up to 1000 kg/ha.

Prospects Upland kangkong is an excellent vegetable, worth promoting in tropical African lowland areas. The introduction of improved Asian cultivars of upland kangkong might be successful especially in areas where sweet potato leaves are traditionally consumed. Locally, conditions are suitable for seed production. Research should focus on the improvement of fertilizer application and non-chemical control of insect damage. Breeding efforts should concentrate on cultivars adapted to specific African environments and resistant to white rust.

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Sources of illustration Westphal, E., 1993.

Authors G.J.H. Grubben

IPOMOEA ERIOCARPA R.Br.

Protologue Prodr.: 484 (1810).
Family Convolvulaceae
Chromosome number $2n = 30$
Synonyms *Ipomoea hispida* (Vahl) Roem. & Schult. (1819) non Zuccagni, *Ipomoea sessiliflora* Roth ex Roem. & Schult. (1819).
Vernacular names Lagaço cozinho, legação cabecinho (Po).
Origin and geographic distribution *Ipomoea eriocarpa* is widespread in tropical Africa including Madagascar, extending to South Africa and Egypt, and occurs also in tropical Asia and northern Australia. In northern Nigeria it is occasionally cultivated; in India it is cultivated on a larger scale for fodder.
Uses The leaves of *Ipomoea eriocarpa* are eaten in Africa and India as a cooked vegetable, in soups or mixed with other food. In Uganda a root decoction is used to speed up fermentation in the preparation of a local drink called 'kwete'; the roots can be found on local markets. In India the seeds are eaten. The plant is a good fodder and in India it is cultivated for this purpose. It is also an effective soil binder and cover plant, which smothers weeds. In Uganda a root decoction is drunk by women to relieve menstrual pain. In India an oil extract of the plant is used externally against headache, rheumatism, leprosy, epilepsy, ulcers and fever. In veterinary medicine the oil extract is used to cure wounds of cattle.
Properties At the flowering stage, fodder of *Ipomoea eriocarpa* in India contains per 100 g: water 16 g, protein 16 g, carbohydrate 35 g and fibre 21g. The fodder is said to be as valuable as sunnhemp (*Crotalaria juncea* L.). The seeds contain per 100 g: protein 22 g, fat 10 g, carbohydrate 44 g, but an irritant purgative resin is also present.
Botany Annual herb with twining or prostrate stems, pubescent or hispid with long and short hairs. Leaves alternate, simple; stipules absent; petiole 1–6 cm long; blade ovate-cordate to linear-oblong, 2–10 cm × 1–7 cm, base usually slightly hastate with rounded lobes, apex acuminate to obtuse, margin entire and pilose-strigose. Inflorescence an axillary (1–)3–many-flowered cyme, bracteate; peduncle up to 1.5 cm long. Flowers bisexual, regular, 5-merous; pedicel c. 0.5 cm long; sepals ovate, up to 9 mm × 4 mm, hispid-pilose, spreading in fruit; corolla tubular to funnel-shaped, up to 1 cm long, slightly lobed, purple, pink or white with a purple centre, with 5 hairy bands outside; stamens inserted near base of corolla tube; ovary superior, long-hairy, 2-celled, style filiform, c. 4 mm long, stigma with 2 globular lobes. Fruit a globose to ovoid capsule c. 6 mm long, hairy, apiculate, opening with 4 valves, up to 4-seeded. Seeds ovoid, c. 5 mm × 3.5 mm, black, finely punctate, glabrous.
Ipomoea comprises about 500 species and mainly occurs in the tropics.
Ecology *Ipomoea eriocarpa* occurs in savanna woodland, grassland, and as a weed on cultivated ground, from sea-level up to 1800 m altitude. In Uganda it occurs in areas with an annual rainfall of 1000–1500 mm, but it is said to be hardy and drought resistant. It can be found on alluvial and sandy soils. In Benin it is a common weed in cotton and sorghum, but absent in yam fields.
Management In Africa *Ipomoea eriocarpa* leaves and roots are collected from the wild whenever needed. Dried leaves can also be stored. Propagation is possible by seed and cuttings.
Genetic resources and breeding *Ipomoea eriocarpa* is widespread and not in danger of genetic erosion.
Prospects *Ipomoea eriocarpa* will remain a minor vegetable, with interesting properties as fodder and a medicinal plant, meriting more research in Africa.
Major references Burkill, H.M., 1985; Gonçalves, M.L., 1987; Katende, A.B., Ssegawa, P. & Birnie, A., 1999; Ruffo, C.K., Birnie, A. & Tengnäs, B., 2002; Williamson, J., 1955.
Other references Deroin, T., 2001; Verdcourt, B., 1963.
Authors P.C.M. Jansen

IPOMOEA OBSCURA (L.) Ker Gawl.

Protologue Bot. Reg. 3: t. 239 (1817).
Family Convolvulaceae
Chromosome number $2n = 30$
Synonyms *Ipomoea fragilis* Choisy (1845), *Ipomoea acanthocarpa* (Choisy) Asch. & Schweinf. (1867), *Ipomoea inconspicua* Bak. (1894).
Vernacular names Obscure morning glory (En).
Origin and geographic distribution *Ipomoea obscura* is widespread in tropical Africa, including Madagascar, the Mascarene Islands and the Seychelles, in South Africa, tropical Asia, northern Australia and Fiji.
Uses The leaves of *Ipomoea obscura* are col-

lected from the wild and eaten as a cooked vegetable in Kenya and added to soup in Nigeria. The plant is also used as fodder for all livestock. In DR Congo leaf sap is used to treat fits of insanity and in eastern Africa a root decoction is drunk against dysentery. In Indonesia a paste of the leaves, mixed with *Argyreia mollis* (Burm.f.) Choisy leaves and alcohol, is applied to open sores and pustules. Dried and powdered leaves are used to treat aphthae. *Ipomoea obscura* has also ornamental value as a climber with attractive flowers.

Properties The leaves of *Ipomoea obscura* are mucilaginous and have a pleasant smell.

Botany Annual or perennial herb with slender, twining or prostrate stem up to 3 m long, glabrous or patently hairy. Leaves alternate, simple; stipules absent; petiole up to 11 cm long; blade usually ovate, sometimes linear-oblong, 2–10 cm × 2–9 cm, base cordate, apex acuminate, margin entire or slightly undulate, pubescent or glabrescent. Inflorescence an axillary 1–few-flowered cyme; peduncle 1–14 cm long, slender; bracts minute. Flowers bisexual, regular, 5-merous; pedicel 1–2 cm long, reflexed in fruit; sepals ovate to lanceolate, 4–8 mm long, often accrescent and reflexed in fruit; corolla funnel-shaped, 2–2.5 cm long, yellow, orange, cream or white with 5 darker bands, often centre dark purple; stamens inserted near base of corolla tube, included; ovary superior, glabrous, 2-celled, style c. 8 mm long, stigma 2-lobed. Fruit a globose to broadly ovoid capsule, 7–10 mm long, apiculate, opening with 4 valves, up to 4-seeded. Seeds ovoid, c. 4 mm long, black, pubescent.

Ipomoea comprises about 500 species and mainly occurs in the tropics. *Ipomoea obscura* is rather variable and several varieties have been distinguished. However, the occurrence of many intermediates makes these subdivisions questionable and without much practical use.

Ecology *Ipomoea obscura* occurs in grassland, thickets, hedges, open forest, waste ground, roadsides and as a weed in cultivated fields, occasionally along sandy beaches, from sea-level up to 1800 m altitude.

Genetic resources and breeding *Ipomoea obscura* is widespread and not in danger of genetic erosion.

Prospects *Ipomoea obscura* will remain a minor vegetable, of local importance only. Its nutritional, medicinal and ornamental values deserve more research.

Major references Burkill, H.M., 1985; Burkill, H.M., 2000; Dibiyantoro, A.L.H. & Schmelzer, G.H., 2001; Gonçalves, M.L., 1987.

Other references Deroin, T., 2001; Kokwaro, J.O., 1993; Verdcourt, B., 1963.

Authors P.C.M. Jansen

ISONEMA SMEATHMANNII Roem. & Schult.

Protologue Syst. veg. 4: 401 (1819).

Family Apocynaceae

Chromosome number $2n = 22$

Origin and geographic distribution *Isonema smeathmannii* occurs in West Africa, from Senegal to Ghana.

Uses In Sierra Leone young leaves of *Isonema smeathmannii* are eaten as a vegetable. In Côte d'Ivoire the Kyama people use the latex to treat old sores.

Botany Climbing shrub up to 5 m tall, branches up to 20 m long, scarcely containing sticky clear or milky latex (most obvious in the roots); main stem c. 2 cm in diameter, branches blackish, branchlets rusty-brown pubescent. Leaves opposite, simple; petiole 3–7 mm long, pubescent; blade oblong to narrowly obovate, 4–12 cm × 2–5 cm, base usually rounded, apex acuminate to apiculate or obtuse, margin entire, leathery, pilose to pubescent beneath, secondary veins 4–6 on each side. Inflorescence usually terminal, thyrsoid, up to 27 cm × 6 cm, densely pubescent; peduncle up to 7 cm long. Flowers bisexual, regular, 5-merous; pedicel 3–5 mm long; sepals broadly ovate, 2–2.5 mm × 1–2 mm, brownish, pubescent outside, bearing 5 groups of 2–3 glands 1 mm long; corolla tube 7–10.5 mm long, glandular pubescent inside, lobes ovate-oblong, 4.5–6 mm × 2–3 mm, red-brown to pink-red inside and with 4 yellow longitudinal stripes, corolla often with lateral appendage; stamens exserted for 3–4.5 mm; ovary superior, consisting of 2 free carpels, style filiform, 8.5–12 mm long, club-shaped at apex and composed of 2 rings above each other, stigma 2-lobed. Fruit composed of 2 widely spreading follicles connate at base, each one cylindrical, 11–20 cm × 0.5–1 cm, velvety rusty brown, many-seeded. Seeds fusiform, laterally compressed, 18–22 mm × 2–3.5 mm, at apex bearing a coma of spreading hairs about 2 cm long.

Isonema is a small genus of 3 species, restricted to West and Central tropical Africa. The other 2 species are *Isonema buchholzii* Engl. (restricted to Nigeria and Cameroon) and *Isonema infundibuliflorum* Stapf (restricted to Cameroon, Gabon and DR Congo). The pres-

ence of unilateral appendages to the corolla distinguishes *Isonema* from related genera.

Ecology *Isonema smeathmannii* grows in scrub vegetation or forest, mainly near the coast, often near water or in swampy locations. Flowering and fruiting has been observed year-round.

Genetic resources and breeding In its area of distribution *Isonema smeathmannii* is rather common and not in danger of genetic erosion.

Prospects *Isonema smeathmannii* is a decorative climbing shrub with red-yellow flowers. The value of its young leaves as a vegetable and its latex as a medicine can only be confirmed after more investigation.

Major references Burkill, H.M., 1985; Huber, H., 1963; van der Ploeg, J., 1983.

Other references Bouquet, A. & Debray, M., 1974; Dalziel, J.M., 1937; Irvine, F.R., 1961.

Authors P.C.M. Jansen

JACQUEMONTIA TAMNIFOLIA (L.) Griseb.

Protologue Fl. Brit. W. I. 5: 474 (1862).

Family Convolvulaceae

Chromosome number $2n = 18$

Synonyms *Ipomoea tamnifolia* L. (1753), *Jacquemontia capitata* (Desr.) G.Don (1837).

Vernacular names Hairy cluster-vine (En). Kikopwe (Sw).

Origin and geographic distribution *Jacquemontia tamnifolia* occurs throughout Africa, including Madagascar and other Indian Ocean islands; it is also found in tropical America.

Uses In Kenya and Tanzania the leaves of *Jacquemontia tamnifolia* are collected from the wild and eaten as a cooked vegetable; in Ghana they are added to soup. The plant is also a good fodder for all livestock. In Nigeria crushed leaves are applied against headache and in Senegal dried powdered leaves, mixed with leaves of *Sarcocephalus latifolius* (Sm.) E.A.Bruce, are taken as a snuff to treat neuralgia. In Tanzania leaf sap is applied against conjunctivitis and ash of the plant mixed with castor oil is rubbed into scarifications to treat leprosy. Juice of leaves and roots is taken as an antidote to treat bites of green mamba snakes and a leaf infusion is used to wash wounds. With its dense inflorescences of bright blue flowers *Jacquemontia tamnifolia* is a beautiful ornamental climber.

Properties Traces of hallucinogenic indole alkaloids are present in the seed of *Jacquemontia tamnifolia*. Plant extracts are slightly insecticidal.

Botany Annual herb with several stems from the base, usually climbing or trailing, occasionally erect, appressed silky hairy. Leaves alternate, simple; stipules absent; petiole up to 5 cm long, densely hairy; blade ovate to oblong or cordate, up to 9 cm × 6 cm, base truncate to cordate, apex acuminate, margin entire, ciliate. Inflorescence a dense, hairy, head-like cyme c. 2.5 cm in diameter, supported by leaf-like to linear bracts; peduncle up to 12 cm long, silky pilose. Flowers bisexual, regular, 5-merous; sepals ovate-lanceolate, c. 5 mm × 1 mm, densely reddish hairy; corolla funnel-shaped, c. 1 cm long, blue, obscurely lobed, glabrous but with 5 hairy bands; stamens inserted at base of corolla tube, included; ovary superior, glabrous, 2–3-celled, style filiform, c. 7 mm long, stigma 2-lobed. Fruit a globose capsule c. 3.5 mm in diameter, glabrous, pale yellow, dehiscing with 4 or 6 valves, 4–6-seeded. Seeds ovoid, c. 3 mm long, brown, scabrid.

Jacquemontia comprises about 120 species, most of them restricted to tropical America. It seems related to *Convolvulus* and *Hewittia*.

Ecology *Jacquemontia tamnifolia* is found in relatively humid locations in woodland, edges of thickets and grassland, and as a weed on cultivated fields, from sea-level up to 1100 m altitude.

Genetic resources and breeding *Jacquemontia tamnifolia* is widespread and not in danger of genetic erosion.

Prospects *Jacquemontia tamnifolia* will remain a minor vegetable of local importance only. Its nutritional, medicinal and ornamental values deserve further investigation.

Major references Burkill, H.M., 1985; Deroin, T., 2001; Ruffo, C.K., Birnie, A. & Tengnäs, B., 2002.

Other references Gonçalves, M.L., 1987; Kokwaro, J.O., 1993; Verdcourt, B., 1963.

Authors P.C.M. Jansen

JUSTICIA FLAVA (Vahl) Vahl

Protologue Symb. bot. 2: 15 (1791).

Family Acanthaceae

Chromosome number $2n = 26$

Synonyms *Justicia sulcata* (Vahl) Vahl (1791), *Adhatoda flava* (Vahl) Nees (1847), *Justicia suaveolens* (Nees) Lindau (1895).

Origin and geographic distribution *Justicia flava* is widespread and occurs all over tropical Africa, but has not been reported from the Indian Ocean Islands; it is also found in the Arabian peninsula.

Uses In Guinea the leaves of *Justicia flava* are used as a vegetable collected from the wild. They are cooked into soup or stew. The plant is also considered as a good forage. In Kenya the plant contributes to sand-binding vegetation in coastal dunes and sandy river banks and leaves are burnt to ash to produce a vegetable salt. In Tanzania the leaves are reported to be emetic, in Côte d'Ivoire haemostatic. Preparations are used on cuts and to treat menorrhagia, and blood in the sputum. The whole crushed plant, mixed with vegetable ash, seed of *Aframomum* species and capsicum pepper is administered by enema against painful menses, or, mixed with lemon juice, taken to induce menstruation. In Côte d'Ivoire the pulped leaves are rubbed on the skin to treat convulsions and feverish pains in babies. In Ghana the plant is used internally and externally against fever, yaws and diarrhoea in children. The inflorescence is said to be a cure for dysentery. An infusion of the plant is taken with egg albumen and coconut juice against palpitations of the heart and leaf sap is used as an eye lotion. In Tanzania leaf sap is taken against hookworm and to treat hydrocele, including bathing the affected parts. The bitter root is chewed by the Masai to cure diarrhoea and coughs.

Properties The composition of fresh *Justicia* leaves per 100 g edible portion is: water 86.8 g, energy 138 kJ (33 kcal), protein 3.3 g, fat 0.4 g, carbohydrate 6.2 g, fibre 1.7 g, Ca 510 mg, P 70 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). Four sterols and salicylic acid were isolated from the leaves, stems and roots of *Justicia flava*. In addition the leaves contain the 3 lignans helioxanthin, (+)-isolariciresinol and justicinol, as well as docosanoic acid and β-sitosterol-β-D-glucoside. The lignans were screened for pharmacological activity in mice, but only a mild effect on the central nervous system, demonstrated by decrease in motor activity and ataxia, was observed.

Botany Erect or trailing, usually perennial herb up to 120 cm tall, pubescent; stem often woody at base. Leaves opposite, simple; petiole up to 1.5 cm long; blade ovate-lanceolate, up to 8 cm × 3 cm. Inflorescence a dense terminal spike up to 20 cm long, continuous or interrupted in the basal part; bracts linear-lanceolate. Flowers bisexual, c. 1 cm long, bright yellow; sepals 5, c. 3 mm long, white hairy; corolla tubular, 2-lipped, lower lip 2-lobed, upper lip 3-lobed; stamens 2, filaments glabrous, one anther cell below the other, tailed; ovary superior, 2-celled, subglabrous, style hairy below, ending in 2 short stigma branches. Fruit a 4-seeded capsule c. 8 mm long, densely hairy, splitting in 2 halves, but remaining connected at base. Seeds compressed globose, brown to black.

Justicia is a large genus comprising 300–600 species. Its taxonomy is badly known and opinions differ about its delimitation because differences between related genera are hardly distinctive. Numerous species can be found in the literature referred to by a variety of names within the genera *Adhatoda*, *Duvernoia*, *Gendarussa*, *Justicia*, *Rostellaria* and *Rungia*. A complete revision of all related genera is urgently needed. *Justicia flava* is classified in the section *Tyloglossa*, characterized by spike-like inflorescences and ammonite-like or rugose seeds, and by its pollen type.

The flowers of *Justicia flava* are much visited by bees and other insects.

Ecology *Justicia flava* grows in open habitats, with a wide ecological range from sea-level up to 2300 m altitude. In dry regions it can grow as an annual with smaller flowers.

Management *Justicia flava* is not cultivated but collected from the wild. In Guinea it is not removed as a weed when occurring in cultivated fields, but allowed to grow to collect its leaves for vegetable use.

Genetic resources and breeding *Justicia flava* is widespread and not in danger of genetic erosion.

Prospects *Justicia flava* will remain a vegetable of minor and local importance only. Its nutritional and medicinal properties need more investigation to discover potential value.

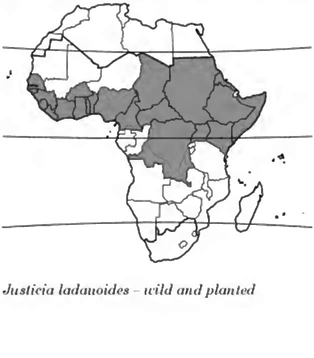
Major references Burkill, H.M., 1985; Burkill, H.M., 2000; Burkill, I.H. & Clarke, C.B., 1899–1900; Busson, F., 1965; Kokwaro, J.O., 1993.

Other references Graham, V.A.W., 1988; Heine, H., 1963a; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Olaniyi, A.A. & Powell, J.W., 1980; Sangat-Roemantyo, H., 1999; Wood, J.R.I., Hillcoat, D. & Brummitt, R.K., 1983.

Authors P.C.M. Jansen

JUSTICIA LADANOIDES Lam.

Protologue Tabl. encycl. 1(1): 42 (1791).
Family Acanthaceae
Chromosome number $2n = 40$
Synonyms *Justicia schimperi* (Hochst.) Dandy (1956), *Justicia insularis* auct. non T.Anders.
Vernacular names Justicia, tettu (En, Fr).
Origin and geographic distribution *Justicia ladanoides* occurs wild from Senegal and Gambia east to Eritrea, Ethiopia and Somalia, but not further south than DR Congo, Kenya and Uganda. It is cultivated in home gardens in West and Central Africa, especially in Guinea, Sierra Leone, Ghana, Togo, Benin, Nigeria, Cameroon and DR Congo.
Uses In tropical Africa, the tender and slightly slimy leaves and shoots of *Justicia ladanoides* are an appreciated leafy vegetable; they are also cooked into soup or stew. Leaves of sweet potato are sometimes added to prepare soup, and in western Cameroon *Justicia ladanoides* leaves are added to groundnut soup. Occasionally, *Justicia ladanoides* is also used as forage and planted as an ornamental. The leaves are used for the treatment of wounds and, mixed with oil and salt, they are eaten to treat cardiac disorder. In Ghana and Togo, a leaf decoction is given to children for the treatment of indigestion.
Production and international trade *Justicia ladanoides* is a low value vegetable, marketed in village markets and occasionally in urban markets. There is no international trade and there are no production data.
Properties The composition of fresh *Justicia* leaves per 100 g edible portion is: water 86.8 g, energy 138 kJ (33 kcal), protein 3.3 g, fat 0.4 g, carbohydrate 6.2 g, fibre 1.7 g, Ca 510 mg, P 70 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968).



Justicia ladanoides – wild and planted

Justicia ladanoides – 1, part of young plant; 2, flowering branch; 3, fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

Description Annual or perennial herb up to 2 m tall; stem angular, glabrous to pubescent, basal part often swollen and with aerial roots. Leaves decussately opposite, simple, almost glabrous to densely pubescent; petiole up to 6 cm long; blade linear or narrowly lanceolate to ovate, obovate or elliptical, 1–11 cm × 0.5–5 cm, base attenuate to truncate, apex obtuse to acuminate, margin entire to crenate. Inflorescence an axillary or terminal congested spike, few-flowered, with narrow bracts. Flowers bisexual, sessile, zygomorphic, 5-merous, usually crimson, sometimes white; calyx up to 1 cm long, with short tube and longer lobes; corolla tubular, up to 2.5 cm long, 2-lipped, lower lip longest and widest and 3-lobed, upper lip narrower and 2-lobed; stamens 2, hidden in upper lip of corolla; ovary superior, 2-celled, style long and slender, stigma with 2 unequal lobes. Fruit an ovoid to ellipsoid capsule c. 10 mm × 3 mm, yellow-brown to white, explosively dehiscent, 4-seeded. Seeds c. 2 mm long, tuberculate.

Seedling with epigeal germination.

Other botanical information *Justicia ladanoides* belongs to section *Harnieria*. It has been confused with species of the so-called *Justicia striata* complex. Some species of this complex are also used as a vegetable in a similar way to *Justicia ladanoides*. An example is *Justicia heterocarpa* T.Anders.; in Tanzania, its leaves are cooked alone or with other vegetables and served with pounded groundnuts or coconut milk. The *Justicia striata* complex comprises many taxa, which are clearly different in some regions, but in other regions the differences become more vague because of intermediates. This has resulted in conflicting taxonomic treatments varying from the acceptance of only a single variable species within the complex to the distinction of 10 species. *Justicia ladanoides* differs from the *Justicia striata* complex in its pollination system.

Growth and development The vegetative growth of *Justicia ladanoides* is slow; it takes several weeks after sowing to cover the soil. Flowering occurs at the end of the rainy season and the beginning of the dry season. The production of shoots is concentrated at the base of the plant 10–15 cm above the soil surface and shoot production continues after flowering. In *Justicia ladanoides* the stigma is receptive at the same time as the anthers are mature. The style exceeds the anthers, and one of the stigma lobes gradually bends down, coming very close to the anthers after some days, thereby gradually increasing the chance of self-pollination. The flowers of the *Justicia striata* complex are protandrous. When the female phase begins, the stamens bend away from the upper lip thereby exposing the style. Pollination is effected by insects.

Ecology *Justicia ladanoides* occurs in a wide range of habitats, from sea-level up to 2600 m altitude, and from moist rainforest to dry savanna regions. It is also found in waste and cultivated land, refuse heaps, grassland and forest edges. It can be found on sandy and loamy soils, but requires rich humus soil and slight shade for optimum growth. It thrives with annual rainfall ranging from 1000–2000 mm, day temperatures of 25–35°C and night temperatures of 20–27°C; it does not tolerate low temperatures.

Propagation and planting *Justicia ladanoides* can be propagated by seed and by cuttings. The seed remains dormant during the dry season and germinates readily with the onset of rains. The number of seeds/g is about 480. Seed production is difficult because the seeds are scattered when the fruits split open. The fruits can be gathered immediately when the colour changes from green to white, or whole branches with infructescences are harvested and dried. The seed may be drilled in rows spaced at 40–50 cm. Young seedlings are thinned, allowing 30–40 cm between plants in the rows. In cultivation it is easiest to take rooted cuttings obtained from the basal parts of the stem. Spontaneous seedlings can be uprooted and transplanted on vegetable beds. Stem cuttings about 15 cm long can also be planted 30–40 cm apart. Planting on well-prepared, raised vegetable beds is required for good vegetative growth.

Management Weeding is needed 2–3 times per growth cycle. Organic manure and fertilizer (e.g. NPK 10–10–20) are beneficial for good vegetative growth. Irrigation 1–2 times per week is desirable during the dry season.

Diseases and pests As a weedy and seldomly cultivated plant, the disease and pest problems in *Justicia ladanoides* are not prominent. Light attack of flea beetles may occur but the plant is reported to be tolerant to *Zonocerus variegatus* attack. *Colletotrichum* fungi may attack full-grown plants causing dark coloration, shrivelling and wilting of the root collar.

Harvesting Young plants of *Justicia ladanoides* can be harvested by uprooting when 3–5 weeks old, but the main harvest is by cutting. The first cutting is at a height 5–6 cm above the ground when the plant height is 20–25 cm, or 6–7 weeks after planting from seed or cutting. Repeated cuttings promote rapid production of shoots. Harvesting can be carried out at 10-day intervals, preferably in the morning or late afternoon to maintain a fresh and attractive vegetable for marketing.

Yield A yield of fresh *Justicia ladanoides* leaves of up to 20 kg per 10 m^2 bed may be obtained from repeated harvests over a 4-month period.

Handling after harvest The leaves and tender shoots are tied into bundles of 0.3–0.4 kg each. Roots of uprooted young seedlings are washed before these are packed for the market. Water is sprinkled at regular intervals on the vegetable to maintain a fresh appearance for marketing.

Genetic resources There is wide variation within *Justicia ladanoides*, even within local types. Improved cultivars are not available and there are no germplasm collections. There is no

immediate threat of genetic erosion of the existing variation. Collection and maintenance of the germplasm is required for genetic studies and selection of improved cultivars.

Prospects *Justicia ladanoides* has no immediate potential of high commercial value like amaranth, celosia and jew's mallow. As a shade-tolerant plant, it has good potential for production under the low light intensity conditions of African home and backyard gardens. The ability of the plant to produce leaves from the rainy season until well into the dry season makes it a good source of a regular supply of vegetables for the family. Its potential use as a dry season vegetable should also be investigated.

Major references Burkill, H.M., 1985; Hedrén, M., 1989; Morton, J.K., 1978; van Epenhuijsen, C.W., 1974.

Other references Gbile, Z.O., 1984; Hedrén, M., 1990; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Martin, F.W. & Ruberté, R.M., 1975; Rehm, S. & Espig, G., 1991; Ruffo, C.K., Birnie, A. & Tengnäs, B., 2002; Stevels, J.M.C., 1990; Terra, G.J.A., 1973; van der Zon, A.P.M. & Grubben, G.J.H., 1976.

Sources of illustration Hedrén, M., 1989; van Epenhuijsen, C.W., 1974.

Authors O.A. Denton

KEDROSTIS LELOJA (Forssk. ex J.F.Gmel.) C.Jeffrey

Protologue Kew Bull. 15: 354 (1962).

Family Cucurbitaceae

Synonyms *Kedrostis hirtella* (Naudin) Cogn. (1881).

Origin and geographic distribution *Kedrostis leloja* occurs throughout tropical Africa, from Senegal east to Ethiopia and Somalia, and south to South Africa; it is also found in Yemen.

Uses In Tanzania the leaves of *Kedrostis leloja* are eaten as a vegetable. They are chopped and cooked, and coconut milk or pounded groundnuts are added. The ripe fleshy fruits are eaten raw, especially by children. The plant is used for fodder.

Botany Perennial, monoecious scandent herb, with tuberous rootstock; stem up to 2 m long, with bristly hairs; tendrils simple, sometimes bifid. Leaves alternate, simple; petiole 2–11 cm long; blade broadly ovate in outline, up to 10.5 cm × 13 cm, usually palmately 3–5-lobed, cordate at base, lobes obovate to triangular or elliptical. Flowers unisexual, regular, 5-merous; male flowers in pedunculate racemes, up to 30-flowered, pedicel up to 11 mm long, receptacle c. 3 mm long, sepals lanceolate, up to 5 mm long, petals 3.5–5 mm long, yellowish or greenish, stamens 5; female flowers solitary, shortly pedicellate, ovary inferior, shortly hairy. Fruit a conical to fusiform capsule 5–7.5 cm × 2 cm, more or less truncate at base, orange to scarlet when mature, dehiscing longitudinally. Seeds subglobose, up to 5 mm long, smooth.

Kedrostis is placed in the tribe *Melothrieae* and is related to *Corallocarpus*. The name *Kedrostis leloja* has been frequently misapplied to *Kedrostis abdallai* A.Zimm., a closely related species known from Somalia, Kenya and Tanzania. It is very possible that the uses recorded refer to the latter or both species. *Kedrostis abdallai* differs in its sparsely hairy stems, fruits tapered towards the base and shorter (1.5–3 mm) petals in male flowers.

Ecology *Kedrostis leloja* occurs in deciduous woodland and bushland, up to 1650 m altitude.

Management Leaves and fruits of *Kedrostis leloja* are exclusively collected from the wild, but it can be easily propagated by seed. It is locally considered a weed of arable land.

Genetic resources and breeding *Kedrostis leloja* is widely distributed and not in danger of genetic erosion.

Prospects The use of *Kedrostis leloja* is very localized and is likely to continue to be restricted. Research on its phytochemistry and nutritional value are desirable.

Major references Berhaut, J., 1975a; Jeffrey, C., 1995; Jeffrey, C. & Thulin, M., 1993; Ruffo, C.K., Birnie, A. & Tengnäs, B., 2002.

Other references Jeffrey, C., 1967.

Authors C.H. Bosch

KEDROSTIS PSEUDOGIJEF (Gilg) C.Jeffrey

Protologue Kew Bull. 15: 355 (1962).

Family Cucurbitaceae

Origin and geographic distribution *Kedrostis pseudogijef* is restricted to Ethiopia, Kenya and northern Tanzania.

Uses In Kenya the leaves and young shoots are eaten with starchy food. In Ethiopia leaves are boiled and eaten in times of food scarcity. When fresh the leaves have an unpleasant smell, which disappears with cooking.

Botany Dioecious liana up to 12 m long; stem up to 10 cm in diameter, with grey or

greyish brown, ridged bark; tendrils simple. Leaves alternate, trifoliolate; petiole 1–3 cm long; leaflets sessile, unlobed or palmately 3-lobed; middle leaflet 1.5–4 cm × 0.5–3 cm, ovate or rhombic, lateral leaflets similar but with asymmetric base. Inflorescence a fascicle often borne on leafless stems, male one shortly racemose, many-flowered, female one 1–8-flowered. Flowers unisexual, regular, 5-merous; male flowers with pedicel 3–5 mm long, receptacle 1.5–2 mm long, sepals triangular, c. 1 mm long, petals 2–3 mm × 1.2–2 mm, greenish-yellow, stamens 5; female flowers with pedicel 1–3 mm long, ovary inferior, pyriform, hispid. Fruit a pyriform-conical, red berry 1–1.5 cm × 1 cm. Seeds pyriform, 6 mm × 3 mm, smooth.
Kedrostis is placed in the tribe *Melothrieae* and is related to *Corallocarpus*.

Ecology *Kedrostis pseudogijef* occurs in deciduous woodland and bushland at altitudes of 600–1800 m. It is drought tolerant.

Management In Kenya *Kedrostis pseudogijef* is planted around houses and along fences. Propagation is done by cuttings, which are planted at the start of the rains.

Genetic resources and breeding *Kedrostis pseudogijef* is limited in distribution, but does not appear to be threatened. So far no particular interest has been taken in the species and no germplasm collections are known.

Prospects *Kedrostis pseudogijef* is of interest as a home-garden crop for dry areas and as such deserves research interest.

Major references Jeffrey, C., 1995; Schippers, R.R., 2000; Zemede Asfaw & Mesfin Tadesse, 2001.

Other references Jeffrey, C., 1967.

Authors C.H. Bosch

LABLAB PURPUREUS (L.) Sweet

Protologue Hort. brit., ed. 1, 2: 481 (1826).

Family Papilionaceae (Leguminosae - Papilionoideae, Fabaceae)

Chromosome number $2n = 22, 24$

Synonyms *Dolichos lablab* L. (1753), *Lablab niger* Medik. (1787), *Lablab vulgaris* (L.) Savi (1824).

Vernacular names Lablab, lablab bean, hyacinth bean, bonavist bean, Indian butter bean, Egyptian bean (En). Lablab, pois boucoussou, dolique d'Egypte, pois antaque (Fr). Labe-labe, feijão cutelinho, feijão padre, feijão da India, cumandatiá (Po). Mfiwi mafuta (Sw).

Lablab purpureus – wild and planted

Origin and geographic distribution Lablab occurs wild in tropical Africa (including Madagascar) and India. Opinions on the region of first domestication vary. It is often stated that it originates as a crop from India or south-eastern Asia, but a north-eastern African origin is more likely because in large parts of tropical Africa wild and cultivated lablab coexist. In Africa it was dispersed by man probably as early as 800 B.C. and it is now found throughout the continent. It is locally cultivated in most tropical areas of South and Central America, South and South East Asia and Australia.

Uses The most popular use of lablab in tropical Africa, e.g. in West Africa, Ethiopia and Malawi, is as a vegetable. The young green pods and immature seeds are eaten boiled. Locally, the young leaves are used as a leafy vegetable. Elsewhere, e.g. in northern Nigeria and Kenya , the dry seeds are eaten as a pulse although they require prolonged cooking with several changes of water. In Madagascar and Mauritius lablab is grown on a small scale for both the green and dry seeds. In Ethiopia lablab is grown locally as field crop for the dry seed. In East Africa the ripe seeds are appreciated by the Indian community, because it is popular as pulse in India.
The whole plant is used as a fodder for cattle, either green or as hay or silage. The stems are stronger and more fibrous than the similar cowpea, and animals tend to eat the leaves only and leave the stems. As an annual or short-lived perennial fodder crop it is grown in Australia on a large scale. In Africa it has been grown for the same purpose by large-scale

farmers in Kenya and Zimbabwe, where lablab hay is fed to animals to supplement poor quality stover and hay. The dry seeds are also used as fodder, but their acceptability is low. In the 1920s, lablab was promoted in the Gezira scheme (Sudan) as a dual-purpose crop: fodder for livestock and seed for human consumption.

In East Africa the leaves are crushed and sniffed to cure headache. They are used as emmenagogue and to accelerate childbirth and to treat stomach troubles. Green leaves crushed in vinegar have been used to treat snakebites. In Rwanda the leaves are taken in a decoction of a mixture with leaves of other plants in case of heart problems. In DR Congo the leaves are made into an infusion which is drunk to cure tonsillitis. In Senegal the seed is given as a stomachic and antispasmodic and has been used in the treatment of cholera and sunstroke. In India lablab is considered a strong antihypertensive, anticholesterolemic, antispasmodic, digestive, hypoglycaemic and is also used as a cure for diabetes, alcohol intoxication and ear inflammation. In South-East Asia the leaf has been used in the treatment of eczema, gonorrhoea and tumours. In Kenya the seeds either baked or heated are used as a veterinary drug to treat eye problems in sheep and lung problems in cattle, goats and sheep.

Lablab is widely grown for soil improvement and in soil and water conservation programmes, but these uses seem rare in tropical Africa. Because of the ease with which various strains of the plant adapt to different environments, the International Institute of Tropical Agriculture (IITA) has promoted the introduction of *Lablab purpureus* as cover crop in plantations in the humid savanna areas of Nigeria. It makes a good cover crop in perennial crops such as coffee and coconut. In Australia it is used as a green manure.

In Zanzibar a green dye was obtained from pounded leaves; in the United States it is occasionally grown as an ornamental.

Production and international trade In tropical Africa lablab is widespread but less popular than some other leguminous vegetables and pulses such as cowpea (*Vigna unguiculata* (L.) Walp.) or bean (*Phaseolus vulgaris* L.). The seeds and pods are offered at many local markets, but there are no statistical data available on production or trade.

Properties The nutritional composition of immature lablab seeds per 100 g edible portion (refuse 7%) is: water 87.9 g, energy 193 kJ (46 kcal), protein 2.1 g, fat 0.2 g, carbohydrate 9.2 g, Ca 50 mg, Mg 40 mg, P 49 mg, Fe 0.7 mg, Zn 0.4 mg, vitamin A 109 IU, thiamin 0.08 mg, riboflavin 0.09 mg, niacin 0.52 mg, folate 62 μg, ascorbic acid 13 mg. The nutritional composition of mature lablab seeds per 100 g edible portion (refuse 0%) is: water 9.4 g, energy 1440 kJ (344 kcal), protein 23.9 g, fat 1.7 g, carbohydrate 60.8 g, Ca 130 mg, Mg 283 mg, P 372 mg, Fe 5.1 mg, Zn 9.3 mg, vitamin A 0 IU, thiamin 1.1 mg, riboflavin 0.15 mg, niacin 1.6 mg, folate 23 μg, ascorbic acid 0 mg (USDA, 2002). The fresh pods of lablab contain per 100 g edible portion: water 87 g, energy 193 kJ (46 kcal), protein 2.9 g, fat 0.45 g, carbohydrate 2.9 g, fibre 1.5 g, Ca 0.6 mg, Mg 37 mg, P 59 mg, Fe 1.2 mg, vitamin A 210 mg, thiamin 0.9 mg, riboflavin 0.08 mg, niacin 0.6 mg, ascorbic acid 11 mg (Rubatzky, V.E. & Yamaguchi, M., 1997).

The dry seeds have a high content of toxic cyanogenic glucosides and trypsine. These toxic compounds are broken down by heat. The content of crude protein in the dry matter of the whole plant and in the leaves is 10–22% and 14.5–38.5%, respectively. As the lower values refer to aged plant material this is a clear indication that lablab can provide a valuable addition to a protein-poor diet of cattle. The leaves are free of tannins.

The seeds contain the flavonoids kievitone and genistein, which play a role in the prevention and treatment of some forms of cancer. Genistein (4',5',7-trihydroxyisoflavone) inhibits capillary proliferation in tumours; it also plays a role in the relief of menopause symptoms by binding to the same receptors as human oestrogen. In the plant the phytoalexin kievitone (2',4',5,7-tetrahydroxy-8-isopentenylisoflavanone) has been shown to provide protection against fungal attack, e.g. by *Aphanomyces* root rot. Antinutritional factors such as haemagglutinins, tannins, phytate and trypsin inhibitors have been reported for the seed. The crushed seed appears not very palatable to livestock, possibly due to the presence of cyanogenic glucosides. Tyrosinase, found in the seeds, lowers blood pressure. In seed of wild lablab high levels of chemicals such as vicilins, α-amylase inhibitors and lectins have been found in quantities that may impart resistance to the bruchid *Callosobruchus maculatus*.

Adulterations and substitutes The pods and immature seeds of *Lablab purpureus* in dishes can be replaced by several other leguminous vegetables, e.g. *Phaseolus vulgaris* L., *Vigna unguiculata* (L.) Walp. and *Pisum sati-*

vum L., all considered more palatable than lablab. Dry lablab seeds used as pulses can be replaced by many pulse species.

Description Climbing or bushy perennial herb, often grown as an annual; taproot well developed, with many lateral roots; stem up to 6 m long, in cultivated plants often erect, pubescent or glabrous. Leaves alternate, 3-foliolate; stipules ovate, c. 5 mm long, reflexed, persistent; petiole 1–18 cm long, rachis up to 4.5 cm long; stipels lanceolate; leaflets ovate-triangular, up to 15 cm × 14 cm, apex acuminate, entire, pubescent to glabrous. Inflorescence an axillary, many-flowered false raceme; peduncle 2–40 cm long, rachis up to 25 cm long; bracts ovate-lanceolate, c. 4 mm long, deciduous. Flowers bisexual, papilionaceous; pedicel short; calyx with tube 3–4 mm long, 2-lipped, upper 2 lobes joined, lower 3 lobes up to 4 mm long; corolla white to deep purple, standard up to 1.5 cm long, keel beaked; stamens 10, 9 fused and 1 free; ovary superior, c. 1 cm long, 1-celled, style laterally flattened, abruptly upturned, stigma headlike. Fruit an oblong-falcate to oblong-linear pod 4–15 cm × 1–4 cm, usually compressed, 2–6-seeded. Seeds ovoid to oblong, compressed, white or red to black; hilum linear; aril whitish. Seedling with epigeal germination.

Lablab purpureus – 1, branch with flowers and young fruits; 2, fruits; 3, seed.
Source: PROSEA

Other botanical information *Lablab* comprises a single species and is closely related to *Dolichos*, which has a more or less rounded style in cross section, a gradually curved keel and short seed hilum. Three subspecies of *Lablab purpureus* have been described. Subsp. *uncinatus* Verdc. comprises wild plants occasionally cultivated in East Africa and then of clearly local origin; it has comparatively small fruits, c. 4 cm × 1.5 cm. Subsp. *bengalensis* (Jacq.) Verdc. is a short-lived, perennial, twining herb grown as an annual in cultivation; it has distinctive tender fruits up to 15 cm × 2.5 cm and is common throughout the tropical and subtropical regions of Africa, Asia and the Americas. Subsp. *purpureus* is a long-lived, semi-erect bushy perennial, but usually grown as annual, showing little or no tendency to climb; the fruits are relatively short, up to 10 cm × 4 cm, and the plant is flushed with purple in all its parts and has a peculiar strong, unpleasant smell; it is grown in Asia as a field crop for the ripe seeds and fodder.

Growth and development Short-day cultivars of lablab start flowering as early as 42 days after sowing depending on sowing date. Flowers are mainly cross-pollinated, but the degree of self-pollination is considerable. Improved cultivars start fruiting 60–65 days after sowing and continue for 90–120 days. Mature seeds are harvested 150–210(–300) days after sowing depending on cultivar and time of sowing. Seeds shatter easily. In cooler climates the plant dies at the end of the growing season, but in the tropics perennial types may persist for 2–3 years.

Lablab roots easily form N-fixing nodules with lablab- or cowpea-type *Rhizobium*, common in tropical soils worldwide. Nitrogen fixation of 180–215 kg/ha has been recorded in 150 days in Australia and 107 days in Ethiopia. In India, inoculation with *Rhizobium* is advised for localities where lablab has not been grown recently, but in Ethiopia inoculation did not increase the amount of nitrogen fixed.

Ecology In the wild lablab occurs in grassland, bushland and gallery forest, up to 2400 m altitude. It is normally a short-day plant, but day-neutral and long-day cultivars exist. Lablab prefers lower elevations but it can thrive well up to 2100 m altitude. The temperature requirement for good growth ranges from 22–35°C. Light frost damages the leaves but does not kill the plants. It grows rainfed in areas with a rainfall of 750–2500 mm/year. Once established (2–3 months after sowing) lablab is

quite drought tolerant. It has a deep root system penetrating to water sources more than 2 m below the soil surface. This permits lablab to grow luxuriously into the dry season. Lablab grows in a variety of soils ranging from deep sands to heavy clays and from acid to alkaline (pH 4.4–7.8) as well as in aluminous soil. It does not tolerate standing brackish water or waterlogging. Provided drainage is good, lablab is tolerant of poor soil texture.

Propagation and planting Lablab is propagated by seed, either broadcast or sown in rows. Germination takes about 5 days. Germination is faster when seeds are soaked in water for 4 hours. The weight of 1000 seeds is 250–500 g, in wild plants 50–120 g. Some 3–4 seeds per hole are sown on flat terrain or on ridges, at a depth of 2–5 cm and at a spacing of 30–45 cm between holes and 60–100 cm between rows. The seed rate required is 30–50 kg/ha; in Australia 15–30 kg/ha is recommended. When grown as a field crop, lablab can be established by broadcasting into roughly ploughed land if the seed is covered to some extent. However, it is usually sown in rows.

Management Climbing cultivars and wild types are widely grown along fences and hedges or supported by sticks or trellises of 2 m tall. Bushy cultivars are commonly grown as a field crop, mostly intercropped with a cereal, e.g. sorghum, millet or maize, or with cotton or castor. It may be relay planted to reduce competition with the cereal. It is also grown in rotation with sorghum and cotton to improve the soil fertility. Lablab suppresses weed growth but some weeding during the early stages of growth is recommended. In India garden cultivars are well fertilized with organic manure or NPK fertilizer. In field cultivation as pulse on fertile soils, fertilizer is rarely applied, but when grown on poor sandy soils 250–500 kg/ha superphosphate and some potash is advised. Although deep rooted and drought resistant when well established, lablab as a garden crop needs regular irrigation in the dry season.

In Australia lablab grown as an annual fodder crop can be grazed when it has formed a full canopy and reached a height of 0.5 m, generally 8–12 weeks after germination. It can be grazed up to 3 times.

Diseases and pest In general, lablab suffers from the same pests and diseases as cowpea but it is more resistant. Anthracnose (*Colletotrichum lindemuthianum*) can cause serious crop losses; spraying with zineb or captan may give reasonable control. Leaf spot (*Cercospora dolichi*) and powdery mildew (*Leveillula taurica* var. *macrospora*) may also be troublesome and are controlled by spraying with fungicides. *Xanthomonas phaseoli* can cause severe defoliation in humid weather. *Sclerotium rolfsii* may cause rotting of the stem bases. In Asia several pests have been recorded on lablab: pod boring larvae (e.g. *Adisura atkinsoni*) are the most serious pest, which can be controlled by spraying with *Bacillus thuringiensis* preparations; in addition, army worm (*Heliothis armigera*), plume moth (*Exelastis atomosa*) and spotted podborer (*Maruca testulalis*) are of economic importance. Insect infestation during storage may be caused by bruchid beetles (*Callosobruchus* spp.), which also attack the crop in the field. Harvesting individual pods as soon as the seed is ripe reduces bruchid infestation. Lablab roots are attacked by several nematodes. There is lack of information on diseases and pests of lablab in Africa.

Harvesting Young immature pods are picked as soon as they have reached a reasonable size, at intervals of 3–4 days. In many cultivars pods ripen in succession on the stem. Harvesting of dry seeds may start 12–15 weeks after planting in early cultivars, and continue until after 45 weeks in late ones. For cultivars with non-shattering pods collection of dry pods can be done after drying on mother plants, but in cultivars with shattering pods they should be collected in several rounds when in the green-ripe stage and then dried on a platform. When senescence starts, the entire plant is sometimes cut close to the ground with a sickle and left to dry for a few days before threshing. For fodder lablab is usually harvested at flowering or in the early green fruit stage.

Yield The average yield of green pods varies from 2500–5000 kg/ha, while the average yield of seed is about 450 kg/ha if grown as an intercrop and up to 1500 kg/ha in sole cropping. In India the cultivar 'Co.9' yields on average 7500 kg/ha of immature pods in 120 days; cultivar 'Highworth' produces over 1.5 t dry seed/ha in commercial exploitation, but in trials yields of over 4 t/ha have been recorded. For 'Highworth' fodder yields of 25–40 t/ha with a total dry matter of 5–11 t/ha have been recorded. In Zimbabwe production of forage amounted to over 9 t of dry matter per ha at 16 weeks after sowing.

Handling after harvest Green pods are cleaned and graded for size, before being packed in baskets for the market. Storage of

green pods at 2–4°C and a relative humidity of 85–90% extend the shelf life to a maximum of 21 days, and of shelled fresh seeds of up to 7 days. In South-East Asia mature seeds are stored in earthenware or metallic containers after being dried and cleaned, and they are covered with a 5 cm protective layer of sand. Reduction of the moisture content to below 10% is effective against bruchid infestation. Seed stored under commercial storage conditions maintains its viability for 3–4 years. There is evidence that white-seeded cultivars lose their viability faster than dark-seeded ones. For animal nutrition lablab can be stored as hay or silage.

Genetic resources More than 250 lines, both indigenous and exotic, are maintained in India at the University of Agricultural Sciences, Bangalore and small collections at Tamil Nadu Agricultural University, Coimbatore and at the Indian Institute of Horticultural Research, Bangalore. The National Genebank of Kenya, Magugu holds over 340 accessions. A germplasm collection is maintained at the legume unit of the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, for evaluation and distribution to farmers to be used as a cover crop. The genetic diversity has been studied using DNA markers. Genetic variation in cultivated lablab appeared to be small, cultivars from India being the most divergent. There was a large difference between cultivated and wild genotypes. Wild plants from Zambia and Zimbabwe were closely related but highly divergent from plants from Uganda. Wild material from West Africa, Namibia, Botswana and Madagascar appears to be lacking in collections. A study on diversity in morphological characteristics in accessions from the collections of CSIRO (Australia) and ILRI (Ethiopia) revealed that in Ethiopia cultivated lablab is very similar in a number of characteristics to the wild African plants and different from the cultivated lablab elsewhere. Based on this study, a core collection of 47 genotypes has been selected for breeding purposes. In Australia and New Zealand, only fodder types are maintained.

Breeding Selection in lablab has been undertaken in Mauritius for use as a vegetable. Most of the improvement work on the climbing vegetable types and bush pulse types is concentrated in India, where several cultivars (e.g. 'Co.9' and 'Co.12') have been released. Desired qualities in improved cultivars are short duration, daylength neutrality, uniform maturity and disease resistance. Elsewhere, breeding is mainly targeted at use as a fodder crop. Bushy, short-duration, day-neutral, disease-resistant cultivars have been obtained. Cultivar 'Highworth' is a popular pulse and forage cultivar from Queensland, Australia. It is quick maturing and yields well in widely differing environments; its pods are non-shattering, mature at much the same time, and grow above the foliage at the top of the stems so that harvesting is made easy. The cultivars 'Rongai' and 'Highworth' are selections from landrace material and have been widely grown in the tropics. The landrace from which 'Rongai' was selected is late flowering and was found in Rongai, Kenya close to the equator. After 'Rongai' was imported in South Africa as a fodder crop for large commercial farms, small-scale farmers started growing it as well for use as a vegetable and pulse crop. These farmers made further selections based on seed colour. As this cultivar is daylength sensitive, it is late flowering, leaf production is high but seed production is late and in southern Africa threatened by early frost. The most recently released cultivar in Australia 'Endurance' is a result of crosses between 'Rongai' and a perennial wild parent. A white-seeded cultivar, 'Koala', has been released in Australia.

Prospects *Lablab purpureus* is a multipurpose species, useful as a vegetable, pulse, fodder, cover crop and green manure, but with different cultivars for these main uses. As a tough plant it is interesting for home gardens but less for market production, where more palatable and productive leguminous crops are available, e.g. *Phaseolus vulgaris*, *Vigna unguiculata* and *Phaseolus lunatus* L. Breeding of vegetable type lablab cultivars should therefore concentrate on palatability, mainly by selecting on tenderness of the seedcoat.

As a pulse and forage crop it does not enjoy much popularity among farmers in tropical Africa, but it is promising because its yields are higher than those of cowpea and its spectrum of adaptability to differing ecological conditions is wider than for any other leguminous plant. It merits attention for breeding and agronomy research. Breeding could pay high rewards if the enormous variation is utilized.

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LACTUCA INERMIS Forssk.

Protologue Fl. aegypt.-arab.: 144 (1775).

Family Asteraceae (Compositae)

Chromosome number $n = 12$

Synonyms *Lactuca capensis* Thunb. (1800).

Origin and geographic distribution *Lactuca inermis* is widely distributed in tropical Africa, Madagascar, South Africa and Yemen.

Uses The leaves and young shoots of *Lactuca inermis* are lightly boiled and eaten in Zimbabwe. In Lesotho the young plants are eaten as a potherb. In Madagascar *Lactuca inermis* is used as a vegetable as well.

An infusion of the leaves (northern Nigeria) or of the boiled roots (Kenya) is drunk as a cure for venereal diseases. In DR Congo the pulverized root is applied to sores, ulcers, leprosy and eczema. The leaves, pounded with natron, are given to horses as a vermifuge in Nigeria.

Botany Perennial, erect herb 5–150(–240) cm tall, sparsely branched, with long, thick taproot. Leaves alternate, sessile, scattered along the stem or crowded on the lower stem; blade lanceolate, sometimes lobed, 5–20 cm × 0.3–1.6 cm (including lobes up to 7 cm wide), base semi-amplexicaul in lower leaves, sagittate higher up, apex acute or mucronate, margin entire or remotely denticulate. Inflorescence a lax or congested panicle of 3–100 heads, with sagittate bracts. Florets 2–14 per head; corolla blue or mauve, rarely pink, yellow or white, tube cylindrical, 4–6 mm long, ligule 6–11 mm × 1–2.5 mm. Fruit a dark-brown to black achene with white pappus.

Variability in *Lactuca inermis*, especially in habit and flower colour, is considerable but continuous.

The leaves of *Lactuca schweinfurthii* Oliv. & Hiern are eaten raw in DR Congo. A related species, *Pterocypsela indica* (L.) C.Shih (synonym: *Lactuca indica* L.; Indian lettuce, wild lettuce) originates from China and is found, most likely as the result of introduction, in the Indian Ocean Islands (Comoros, Madagascar, Seychelles and Mauritius), Mozambique and South Africa. In Asia it is widely used as a vegetable but no uses are recorded for tropical Africa. Although potentially a valuable vegetable, it should not be promoted because of its weedy nature. The sap of the inflorescence stalk of *Lactuca schulzeana* Büttner, a species restricted to Angola and DR Congo, is given to children as a vermifuge.

Ecology *Lactuca inermis* is a pioneer species found in grassland, fallow land and roadsides. Its altitudinal range is (650–)1000–2800(–3450) m in East Africa and 1200–2000 m in Madagascar. It flowers throughout the year, often without leaves being present.

Genetic resources and breeding *Lactuca inermis* occurs widespread in Africa and is not liable to genetic erosion. Although wild *Lactuca* species might be interesting for breeding, the African species are under-represented in genebanks. Only 3 accessions of *Lactuca inermis* could be traced and even these might well be duplicates of 1 entry.

Prospects Interest in *Lactuca inermis* as a vegetable will remain localized. It might attract attention from lettuce (*Lactuca sativa* L.) breeders as a source of pest and disease resistance and heat tolerance. The medicinal uses might be substantiated by research into its chemistry.

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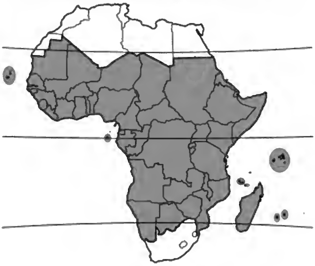
LACTUCA SATIVA L.

Protologue Sp. pl. 2: 795 (1753).
Family Asteraceae (Compositae)
Chromosome number $2n = 18$
Vernacular names Lettuce (En). Laitue (Fr). Alface (Po). Saladi (Sw).

Origin and geographic distribution The origin of lettuce is in Turkey and the Caucasus or the Middle East. The ancestor is probably the European prickly lettuce (*Lactuca serriola* L.), that crosses easily with the cultivated forms. Lettuce was known as a vegetable in the Mediterranean as early as 4500 BC; it was depicted in Egyptian tombs in 2500 BC and cultivated by the Greeks and Romans as a popular vegetable. In Western Europe, headed types have been known since the 14th century but leafy types have been known for much longer. At present lettuce, especially the headed types, is the world's most important salad crop. Salads are traditionally more popular in temperate areas than in the tropics, but lettuce is increasingly important in Africa as an exotic, European type of vegetable, grown for the city markets, supermarkets, restaurants and hotels. It can be found in all African countries, most frequently at higher elevations and in the cooler season, and more often in francophone than in anglophone countries.

Uses Lettuce is grown for its leaves, that are usually eaten raw as a salad with a dressing of oil and vinegar. Occasionally lettuce is used as a cooked vegetable, especially in lowland areas. In China, a form of lettuce with a thickened stem is eaten as a cooked vegetable.

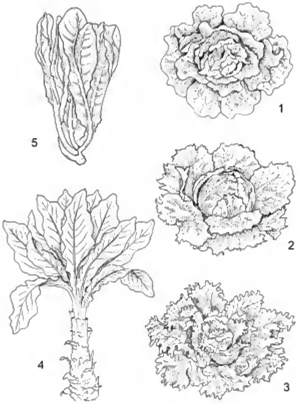
Production and international trade World-wide, lettuce is one of the leading vegetables, with a registered area of about 880,000 ha producing some 20 million t of marketed product. With about 370,000 ha, China is the main producer followed by the United States with 125,000 ha. Other important lettuce producers are the European Union, Japan and India.
In tropical Africa salad vegetables are less popular and lettuce production is modest, although widespread. Lettuce consumption is concentrated in the urban centres, especially in francophone countries. Statistical data on cultivated areas and production in Africa are lacking. Since lettuce is a very perishable product destined for urban consumption, it is mainly produced in the proximity of the big cities. In Africa, it is rarely if ever traded internationally.



Lactuca sativa – planted

Properties After removal of the outer leaves of fresh iceberg lettuce, the composition of the remaining edible portion (83% of the weight) per 100 g is: water 95.6 g, energy 53 kJ (13 kcal), protein 0.7 g, fat 0.3 g, carbohydrate 1.9 g, dietary fibre 0.6 g, Ca 19 mg, P 18 mg, Fe 0.4 mg, β-carotene 50 μg, thiamin 0.11 mg, riboflavin 0.01 mg, niacin 0.3 mg, folate 53 μg, ascorbic acid 3 mg. The carotene value of the pale green to white inner leaves is low, while the darker green outer leaves may contain 50 times as much carotene. In general headed types with a low chlorophyll content (pale green leaves) have fewer micronutrients than leafy types; the dark green types have considerably larger amounts of carotene, Fe and vitamin C. The composition of butterhead lettuce per 100 g edible portion (76%) is: water 94.4 g, energy 52 kJ (12 kcal), protein 0.9 g, fat 0.6 g, carbohydrate 1.2 g, dietary fibre 1.2 g, Ca 53 mg, Fe 1.5 mg, β-carotene 910 μg, thiamin 0.15 mg, riboflavin 0.03 mg, niacin 0.5 mg, folate 57 μg, ascorbic acid 7 mg (Holland, B., Unwin, I.D. & Buss, D.H., 1991).
The presence of free nitrates is seen as a negative quality factor causing health problems to susceptible individuals. In the Netherlands, the legally tolerated maximum content of NO_3 is 2.5 mg per g fresh weight. The nitrate content decreases with increasing light intensity and is no problem in tropical countries. Lettuce contains a milky juice in which several lactones have been identified including lactucin and lactucopicrin, both with analgesic and sedative properties. Many cultivars contain anthocyanin.

Description Glabrous, annual herb up to 100 cm tall, containing latex, forming a dense



Lactuca sativa – 1, habit (butterhead lettuce); 2, habit (crisp lettuce); 3, habit (bunching lettuce); 4, habit (stem lettuce); 5, habit (cos lettuce). Source: PROSEA

basal rosette and later a tall, branched, flowering stem; root system shallow, but with a strong, fleshy taproot. Rosette leaves loose or arranged in more or less compact heads; petiole short; lamina undivided to sawtoothed or pinnatifid, sometimes curly and fringed, pale to dark green or with red or brown anthocyanin pigment; stem leaves arranged spirally, sessile, progressively smaller, ovate to orbicular in outline, entire, cordate-amplexicaul. Inflorescence a head; many heads arranged in a dense, corymbose, flat-topped panicle; involucre 10–15 mm long, consisting of 3–4 rows of lanceolate or ovate bracts. Flowers 7–35 per head, bisexual; corolla ligulate, yellow; stamens 5, with connate anthers; ovary inferior, 1-celled, style bifid. Fruit a narrowly obovate achene 3–8 mm long, compressed, ribbed, white, yellowish, grey, brown or black, with narrow beak, surmounted by a white pappus of 2 equal rows of soft hairs. Seedling with epigeal germination.

Other botanical information The many hundreds of cultivars can be grouped in types or cultivar-groups. Cultivars of different types may easily be crossed among each other and spontaneous crossings occur. Intermediate types exist, making a completely clear distinction difficult. The following 4 types (defined as cultivar-groups in PROSEA 8: Vegetables) occur in tropical Africa, ordered by decreasing importance.

- Crisp lettuce, also named: iceberg lettuce, ice lettuce, cabbage lettuce. Thick crispy leaves, outer leaves dark green, with prominent flabellate veins and midribs; mostly cultivars with heavy firm cabbage-like heads weighing up to 1 kg, interior white to creamy yellow. Non-heading or slightly heading types occur. This is the most popular lettuce type in warm temperate and in subtropical areas, in tropical highlands and during the cool season in the lowland tropics. The standard cultivar type is 'Great Lakes', but there are many other cultivars, e.g. 'Reine des Glaces' (early, resistant to heat and bolting), 'Minetto' (very early, small, heat resistant, resistant to tipburn) and 'Trinity' (compact, heavy, resistant to heat, tipburn, bolting, *Cercospora*, *Sclerotinia*). 'Batavia' is a crisp lettuce type originating from France, with thinner, undulated leaves, heads medium heavy, weighing up to 500 g, firm or loose. It is popular in francophone countries. Standard cultivar type is 'Blonde de Paris', and the traditional American cultivar called 'Iceberg' also belongs to this group. The African cultivar 'Blonde de Yamoussoukro' was developed in Côte d'Ivoire.
- Bunching lettuce: leaf lettuce, loose-leaf lettuce, curled lettuce, cutting lettuce. Leaves thin, broad, smooth, curled or crinkled, green or reddish, in a loose rosette or on a short stem; marketed in bunches of 3–10 plants. Common in African countries. Standard cultivar types are 'Salad Bowl', 'Simpson', 'Oakleaf', but many cultivars exist.
- Butterhead lettuce: head lettuce. Soft solid or loose heads of overlapping leaves, pale green, inner leaves thin, oily, buttery in texture, slightly undulate. Heads of up to 350 g. Originated in Western Europe. Butterhead is a popular lettuce type in temperate climates, but less common in the tropics. A standard cultivar type is 'May Queen', and many cultivars exist, e.g. the heat resistant 'Kagraner'.
- Cos lettuce: romaine lettuce. Long narrow leaves, forming an upright, cylindrical head. Eaten raw or cooked. Originated in southern Europe. Fairly common in francophone countries and in Sudan. Standard cultivar type is 'White Parish Cos'; few cultivars exist, e.g. 'Verte Maraîchère'.

A fifth type, not reported from tropical Africa, is stem lettuce: asparagus lettuce, celtuce. This type is grown for the fleshy 30–50 cm long and 3–6 cm thick stem, that has a crisp texture and a faint lettuce taste. The stem bears many leaves with a rosette at the apex; the young leaves are also edible. Stem lettuce originated in China and is popular in East Asia and locally in South-East Asia. The standard cultivar type is 'Celtus'. Oilseed lettuce is a primitive type with larger seeds, grown in Egypt for the cooking oil pressed from the seed.

Growth and development The seed germinates within 1–4 days, at temperatures from 15–25°C. Young seed less than one month old shows some dormancy with retarded germination. Lettuce seed often shows dormancy when it has been stored at high temperature and is sown at a soil temperature above 25°C, which is the normal situation in tropical lowland. The best remedy is to store the wetted seed in a refrigerator at 2–5°C for 1–3 days. Growth of young lettuce plants is exponential, slow in the beginning and very fast in the last weeks before the harvest stage. Rosette formation becomes apparent in the third week after emergence, and head formation in headed types two weeks later. Depending on growing conditions and cultivar, the head is fully formed and ready for harvesting about two months after sowing. Plants start bolting when 2–3 months old. Inflorescence development of headed cultivars is stimulated by removal of the upper part of the head. The flowering stage may last 1–2 months. The flowers are open for 1–2 hours in the morning and do not open all at once. Lettuce is an obligate self-pollinating crop. Spontaneous cross-fertilization rarely occurs (less than 1%). Seed matures in 9–13 days after anthesis, depending on temperature. Seed is produced abundantly, 10–30 g per plant.

Ecology Lettuce grows best at moderate day temperatures of 15–25°C and cool nights of 10–15°C. In the tropics it thrives best in the highlands and during the cool season. Above 25°C, headed cultivars usually form a loose head. When day temperatures rise above 28°C, the heads will be very loose or no head formation will take place. Heat tolerant cultivars have a better head formation at high temperatures. Crisp lettuce is better adapted to high temperatures than butterhead lettuce. Lettuce grown in tropical lowlands is either the bunching type, or densely grown crisp lettuce harvested as bunching lettuce. Lettuce shows a slight quantitative long-day reaction, but most modern cultivars are almost day-neutral. Bolting is strongly promoted by high temperatures. Lettuce can be grown on any soil type with a good structure and high fertility. The water-holding capacity is important because lettuce has a relatively small root system, which makes the crop vulnerable to drought. Lettuce is often grown on neutral sandy-loam soils (pH 6.5–7.2). It does not tolerate acid soils (pH < 5.5). In temperate countries lettuce is partially grown out of season and often in greenhouses.

Propagation and planting Lettuce is propagated by seed; the 1000-seed weight is 0.8–1.2 g. Many lettuce farmers in Africa use seed of their own selection and only about half of the seed required in Africa is imported. Especially in semi-arid regions it is easy to produce good lettuce seed, but if not properly stored. lettuce seed loses its viability very fast. Plants of headed types are normally raised in a nursery. Seeds are sown in a shaded seedbed, the seedlings pricked out 2–3 weeks after emergence, and planted in the field or in soil blocks of about 4 cm × 4 cm, which are planted out in the field 2–3 weeks later. Somewhat older plants are sturdier and easier to handle. With optimal cultural practices, the seed requirement is only 200 g/ha (1 g seed for 50 m^2), but under suboptimal conditions the seed requirement is much higher. Crisp lettuce can be planted out in the field at 50 cm between rows and 30 cm within the row (66,000 plants/ha) or at 35–60 cm × 35 cm (50,000–90,000 plants/ha). Butterhead lettuce may be planted somewhat closer together. depending on the mature head size of the cultivar, at 25 cm × 20–25 cm. The spacing for cos lettuce can be even narrower, although farmers may prefer to leave a path of 45 cm between double rows spaced at 15 cm. Bunching lettuce is usually sown directly in the field in drills 20 cm apart, and thinned to 5–10 cm, 10–20 days after emergence. African farmers often plant very dense, at 7–9 cm × 7–9 cm. Crisp lettuce like 'Great Lakes' or 'Blonde de Paris' is also often planted densely to produce a bunching type lettuce. The seed requirement for direct sowing under optimal conditions is about 0.5 kg per ha, or 1 g seed per 20 m^2. Heading lettuce is also sown directly in the field. In that case, plants should be thinned to 30 cm within the row. In strongly mechanized cultivation in western countries headed lettuce is sown directly in the field, using pelleted seed and precision drilling equipment.

Management Young lettuce cannot compete

with fast-growing weeds. Several weedings are needed in the first month when the soil surface is not yet covered by the lettuce plants. In addition, the water supply must be very regular. The farmers normally sprinkle their lettuce beds twice daily, during the morning and in the evening, or during the day. The evapotranspiration increases fast, from 2–3 mm/day in the first weeks to 6–8 mm for a full-grown crop. Sprinkling the crop with water from a polluted source such as a local stream containing sewage or passing through dumping grounds should be avoided because of health risks.

Lettuce is a crop with a moderately high uptake of minerals. Depending on the soil conditions, a suitable fertilizer recommendation is 30 t/ha of farmyard manure combined with 50 kg N, 45 kg P and 65 kg K before planting. Many farmers only use poultry manure, applied freely and worked into the beds before planting. An N side dressing of 50 kg/ha is given 3 weeks after planting and again 3 weeks later if needed. The mineral uptake (N, K) is low during the first month after sowing and highest in the last weeks before harvest. Too much nitrogen makes the crop susceptible to tip burn and diseases, and increases the content of nitrate in the harvested product.

The physiological disorder tip burn is probably the most serious problem of lettuce in the tropics. The symptoms are an internal necrosis of the leaf margins in the head, often followed by bacterial rot. The necrosis is caused by water shortage in hot weather and fast growing conditions, which lead to Ca deficiency in the young leaves. It can be controlled by use of tolerant cultivars, liming before planting, slowing down of the growth by limiting the N-fertilizing, a light shading and especially by always keeping an ample and even supply of soil moisture.

Diseases and pests Many fungal, bacterial and viral diseases infest lettuce in the tropics. Common diseases are mosaic virus, bottom rot and downy mildew. Mosaic is caused by lettuce mosaic virus (LMV). It may be controlled by the use of healthy seed, control of aphids and immediate removal of diseased plants. Bottom rot caused by *Rhizoctonia solani* commonly occurs under wet conditions. The symptoms are a slimy rotting of the underside of the plant, progressing into the head. *Sclerotinia* causes a wet rot of the entire plant, beginning at the stem base. Downy mildew caused by *Bremia lactucae*, the most serious disease of lettuce in temperate areas, occurs in cooler parts of the tropics. The best control of bottom rot and *Sclerotinia* is good sanitation, crop rotation and drainage. It is recommended to plant on ridges instead of on flat land. Downy mildew is controlled by the use of cultivars with resistance to the relevant race of the fungus or by spraying with fungicides. Damping-off (*Pythium*), grey mould (*Botrytis*) and leaf spot (*Cercospora*) are also reported. *Cercospora longissima* caused heavy losses on lettuce in Côte d'Ivoire. Infection takes place at high humidity by splashing from the soil, and control is possible by less dense planting and by spraying with benomyl.

The most serious pest are aphids, especially in headed lettuce, because they cannot be controlled easily by spraying with chemicals, which is, moreover, risky because of residues. Other pests are cut worm (*Agrotis*), army worm (*Spodoptera*) and other caterpillars, leaf hoppers, snails and slugs, and root-knot nematodes. Insect pests are usually controlled by spraying chemicals. Nematodes in lettuce can be kept under control by crop rotation, disinfection of the seedbed or nursery soil by heating, and fertilizing with ample organic matter, e.g. manure.

Harvesting Harvesting of headed lettuce is commenced when the heads are fully developed, usually 60–80 days after planting. Harvesting is done by cutting the plants at their base. Bunching lettuce and densily planted heading cultivars are mostly uprooted for bunching. Old outer leaves are trimmed off. Bunching lettuce is usually harvested between 30–50 days after sowing, but can be harvested at any time from the young stage until bolting starts. The younger it is, the more tender the lettuce will be, but also the lower the yield.

Yield For headed lettuce a yield of 70% or more of the number of plants originally planted may be considered a satisfactory result. Successful farmers may reach 90%. The average world yield is about 20 t/ha. Yields above 30 t/ha are reported from temperate areas, but in the tropics they are much lower. In tropical highland a harvest of 50,000 heads/ha with an average weight of 200–300 g yielding 10–15 t/ha is reachable. Crisp lettuce in the Kenyan highlands is reported to yield 15 t/ha with heads of 300–500 g. Yields of bunching lettuce reach only 3–8 t/ha. Stem lettuce harvested at 80–100 days after planting may yield up to 20 t/ha.

Handling after harvest Lettuce wilts easily. The most suitable packing of headed lettuce is in open-topped polythene bags which

are put in crates or boxes. Fast cooling to 0–2°C and packing with ice improve keepability. Commercial market gardeners may dip the cleaned heads in cold water and immediately put the produce in a cool place. Headed lettuce is further trimmed if old or damaged outer leaves are still present. In Nigeria, much lettuce is produced in the savanna area, packed in jute bags and transported over long distances to the cities in the south, resulting in high losses. Plants of headed cultivars which have not produced a head of marketable size (less than 150 g) are often uprooted or cut and bundled in bunches of 3–8 plants. Uprooted lettuce in street markets is kept fresh by putting the roots in a basin with water. It is advisable to wash lettuce carefully before serving to avoid intestinal diseases and parasites.

Genetic resources Large germplasm collections of lettuce and wild *Lactuca* species are kept at institutes in the Netherlands (Centre for Genetic Resources, Wageningen), Russia (Vavilov Institute of Plant Industry, Petersburg), United Kingdom (Institute of Horticultural Research, Wellesbourne) and the United States (National Seed Storage Laboratory, Fort Collins, Colorado).
Lettuce was introduced in Africa centuries ago. Local selections or landraces have developed which may contain valuable genes for disease resistances, heat tolerance, and other traits. There is a great risk of genetic erosion of this material, since seed companies promote improved cultivars.

Breeding Many hundreds of cultivars have been bred in temperate countries (Europe, North America, Japan) with a large variation of very specific characters. Resistance to mosaic and downy mildew is common, and cultivars with resistance to aphids, tip burn and bottom rot occur. Important selection criteria for tropical headed lettuce cultivars are heat resistance, a short growing period, slow bolting, and compact heads that are not easily damaged during transport. The seed company Tropicasem in Senegal performs lettuce breeding for African conditions.

Prospects The popularity of lettuce in tropical countries is increasing. Lettuce will be increasingly grown for city markets and export. Research should focus on breeding of tropical cultivars resistant to pests and diseases and on non-chemical control of diseases and pests.

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Sources of illustration Grubben, G.J.H. & Sukprakarn, S., 1993.

Authors G.J.H. Grubben
Based on PROSEA 8: Vegetables.

LAGENARIA SICERARIA (Molina) Standl.

Protologue Publ. Field Columbian Mus., Bot. Ser. 3: 435 (1930).

Family Cucurbitaceae

Chromosome number $2n = 22$

Synonyms *Cucurbita lagenaria* L. (1753), *Cucurbita siceraria* Molina (1782), *Lagenaria vulgaris* Ser. (1825), *Lagenaria leucantha* (Duchesne ex Lam.) Rusby (1896).

Vernacular names Bottle gourd, calabash gourd, common gourd, white-flowered gourd (En). Gourde, calebasse, courge bouteille (Fr). Cabaceiro, cabaça, abóbora carneira, colombro (Po). Mbuyu, mmumunye, mmung'unye (Sw).

Origin and geographic distribution *Lagenaria siceraria* is one of the earliest domesticated plants and has a pantropical distribution. Its origin is believed to be in Africa, but its wild progenitors have not been identified with certainty. Recently, a wild specimen close to *La-*

Lagenaria siceraria – planted

genaria siceraria has been recorded from Zimbabwe. Bottle gourd may have been spread by ocean currents to the shores of the New World or by human migration in prehistoric times. It is known to have been cultivated in Africa, Asia and the New World in pre-Columbian times. The earliest evidence of its use comes from Peru dating from 13,000–8000 BC. *Lagenaria siceraria* also spread at a very early date throughout tropical and subtropical Asia. The earliest remnants from Japan date back to 6000–4000 BC. In Africa, the oldest remnants were found in Egypt and Zambia and date from 3000–1000 BC. Bottle gourd has probably been domesticated independently in Africa, South America and Asia. The independent domestications are reflected in the variability of commercial cultivars.

The use of bottle gourd as a container is reported from most parts of the tropics and subtropics of the world, including all countries of Africa. Its use as a vegetable is more restricted.

Uses Bottle gourd is cultivated for a wide range of uses including food, storage, utensils, and medicine depending on cultivar and custom. Young, tender, non-bitter fruits are used as a vegetable. They are cut or peeled, and then boiled for 10–15 minutes until soft. Salt may be added to the product that is then eaten as a snack. The young fruits are also mashed, salted and fried and used as a stew. Without added condiments, they are slightly sweet or have a bland taste reminiscent of avocado. Some types are bitter even when young and these are not eaten. In areas where bottle gourd is not eaten, local landraces are often bitter. Young shoots and flower buds of less bitter types are occasionally eaten as a green vegetable. The shoots are boiled with milk or coconut milk to reduce the unpleasant, peculiar flavour. They may also be mixed with other leafy vegetables, e.g. *Asystasia gangetica* (L.) T.Anderson, *Cleome gynandra* L., *Corchorus olitorius* L., *Cucurbita moschata* Duchesne, *Launaea cornuta* (Hochst. ex Oliv. & Hiern) C.Jeffrey or *Vigna unguiculata* (L.) Walp. In Congo, some cultivars have edible leaves, but in most communities the leaves are eaten only as an emergency food.

In West Africa, Botswana, Zimbabwe and South Africa, people extract an edible oil from the seed. In southern Africa this oil is used when alternative vegetable oils are scarce or when disposable incomes are very low, but in West Africa the oil is commonly available in markets. The seeds of less bitter types are roasted and consumed as a snack or pounded and mixed with maize or millet flour. In Asia, where many of the above-mentioned uses are also found, some bottle gourd cultivars are used as a rootstock for grafting musk melon, watermelon and cucumber to control soilborne diseases. In Japan, long strips of fruit skin are commonly boiled, soaked in soya sauce with a little sugar, and used as an ingredient of 'sushi'.

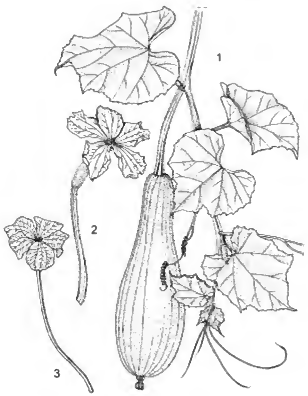
Roots and fruits are sometimes used as a purgative. The leaves are used as a medicine for stomach-ache, skin rashes and swelling due to snake poison. The myriad of sizes and shapes of the fruits, both genetically and environmentally determined, accounts for the tremendous variation in the use of the dry shell (calabash) as containers and utensils in many parts of the world. Calabashes are used for storing and transporting drinking water, porridge, fresh or fermented milk, local beer and wine, honey, ghee, animal fat, salt, tobacco, perfume, medicinal herbs, crop seeds or food grains. They are also made into beehives, containers for brewing beer or keeping clothes (like a suitcase), or into animal traps and decoys, animal feeders, air pumps, well buckets, vases, funnels, floats for fishing nets, beds for babies, washbasins, irrigation pots, cages for chicks, masks and containers for seedlings. Calabashes are used to make many musical instruments. The Luo of Kenya make a large traditional bugle from bottle gourds, blown during ceremonies and for chasing away wild animals. In West Africa calabashes may be used as resonance boxes for the kora (harp or lute) and balafon (xylophone). The Bavenda of southern Africa also use calabashes to make xylophones. Smaller types are used to make single-wire traditional guitars or fiddles. Other musical instruments made from calabashes include drums, wind instruments, rattles and hand pianos. Kikuyu sorcerers of Kenya use calabashes for divination by the casting of lots and to anoint circumcision initiates and marriage couples. The Luo in Kenya traditionally use them for smoking cannabis (*Cannabis sativa* L.). They are also used for manufacturing necklaces, earrings and other accessories. Large halves are commonly used for winnowing grain, the smaller sizes are cut at the top or in halves and used as a drinking cup or as ladles. The use of bottle gourd is deeply associated with local culture among African communities. Songs, proverbs, stories, beliefs and myths are associated with bottle gourd in almost every community.

Production and international trade Bottle gourd as a vegetable is mainly cultivated for home consumption, although excess young edible fruits are sometimes sold in local markets. The products made from bottle gourd shells are commonly traded in local markets. The seed oil is occasionally traded in West and southern Africa as cooking oil.

Properties The composition of immature fruits of bottle gourd per 100 g of fresh edible portion is: water 93.9 g, energy 88 kJ (21 kcal), protein 0.5 g, fat 0.1 g, carbohydrate 5.2 g, fibre 0.6 g, Ca 44 mg, P 34 mg, Fe 2.4 mg, β-carotene 25 μg, thiamin 0.03 mg, niacin 1.2 mg, ascorbic acid 10 mg. The composition of the leaves per 100 g of fresh edible portion is: water 83.7 g, energy 180 kJ (43 kcal), protein 4.4 g, fat 0.3 g, carbohydrate 8.3 g, fibre 1.8 g, Ca 560 mg, P 88 mg, Fe 7.4 mg. This composition is in line with other medium-green leafy vegetables. The seed contains per 100 g edible portion: water 3.2 g, energy 2410 kJ (574 kcal), protein 28.2 g, fat 49.8 g, carbohydrate 14.6 g, fibre 2.0 g, Ca 75 mg, P 1100 mg, Fe 5.3 mg, thiamin 0.40 mg, riboflavin 0.26 mg, niacin 4.6 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). The oil is rich in linoleic acid (about 60%), but contains only 0.1% linolenic acid. One of the major bitterness components of the bitter fruits is the poisonous cucurbitacin B. Elaterase, an active β-glucosidase, has been isolated from the juice of bitter fruits; it is an enzyme for hydrolysis of the bitter principles of the *Cucurbitaceae*, capable of splitting glucose from tri-glucosides and tetra-glucosides. In an experiment, the flesh of bitter fruits fed to rabbits caused restlessness and dyspnoea with death from asphyxia, and paralysis in one animal.

Adulterations and substitutes In cooking, pumpkin leaves can be used as a substitute for bottle gourd leaves. The seeds can be replaced by seeds of other *Cucurbitaceae* species, e.g. *Citrullus lanatus* (Thunb.) Matsum. & Nakai, *Cucumeropsis mannii* Naudin, *Cucurbita maxima* Duchesne. For storage purposes, it can be replaced by the fruits of the tree calabash (*Crescentia cujete* L.) or by containers made of other materials.

Description Monoecious, annual, climbing or trailing herb, with proximally bifid tendrils. Leaves alternate, simple; stipules absent; petiole 2.5–12.5 cm long, pubescent, with a pair of tiny glands at apex; blade broadly ovate to kidney-shaped in outline, 3–33 cm × 4.5–33 cm, undivided or shortly palmately 5–9-lobed, cordate at base, shallowly sinuate-dentate, pal-



Lagenaria siceraria – 1, flowering and fruiting shoot; 2, female flower; 3, male flower.
Source: PROSEA

mately veined. Flowers unisexual (rarely bisexual), solitary in leaf axils, regular, 5-merous, up to 15 cm in diameter; receptacle tube obconic-cylindrical, 1–1.5 cm long, lobes remote; petals free, white; male flowers on long pedicels 7–31 cm long, with 3 free stamens inserted on the receptacle tube, connectives broad; female flowers on short pedicels 2–10 cm long, with inferior, densely hairy ovary, stigma 3-lobed, thick, each lobe 2-lobed. Fruit a berry, very variable in size and shape, often globular, bottle- or club-shaped, up to 1 m long, white-yellow to dark green when young, sometimes whitish speckled, usually brown when mature and dried, with hard, durable rind, flesh white and soft, many-seeded. Seeds oblong, compressed, up to 2 cm long, emarginate at base, with 2 flat facial ridges, smooth, sometimes rugose, whitish to brownish.

Other botanical information *Lagenaria* comprises 6 species, 5 of these occurring wild in Africa. These wild species are perennial and have spherical to ellipsoid, small-sized bitter fruits with a slimy juice containing saponins. The cultivated *Lagenaria siceraria* is polymorphic and has numerous landraces; its phenotypic variation is continuous and difficult to

quantify. The hard and thick rind and well-developed 'handle' of the fruit are often characteristic, but in Kenya local edible types are small and round. In some communities, fruits with a warted surface are selected for consumption. The variation in fruit shape is larger than that in seed shape and there is no correlation between fruit and seed shape.

Growth and development Emergence of the seedling occurs 4–5 days after sowing. The vining stage starts 2–3 weeks after emergence with rapid elongation of lateral stems and growth of tendrils. Growth slows down at the onset of flowering. Male flowers appear 8–18 weeks after planting, female ones 2–4 weeks later. The female flowering period lasts 3–12 weeks depending on cultivar and environmental conditions. In some cultivars, a secondary flowering period occurs during the next rainy season from the stems that survived the dry season. Female flowers are formed on the auxiliary stems, and rarely towards the tip of the main stem. Female flowers in the lower leaf axils have a greater chance of developing fruits than those appearing higher up on the stem. Female flowers at the end of the creeping branches develop smaller fruits or dry up. Flowers open in the evening and close after 8–20 hours. The stigmas are receptive from 6 hours before to 36 hours after anthesis. Male flowers open earlier and close later than female ones. There are more male flowers than female flowers, the ratio being approximately 9:1, although it is lower at low temperatures. The flower ratio also depends on cultivar. Pollination is mainly by bees; hawkmoth (*Hippotion celerio*) and a skipper butterfly (*Gorgyra johnstoni*) are major pollinators in Kenya. For seed production, fruits need 2–3 months to mature.

Ecology Bottle gourd is widely cultivated in the tropics from sea-level to 2500 m altitude, and is found as an escape especially along riversides and lakeshores. It needs a well-distributed rainfall of 600–1500 mm and is adapted to semi-arid conditions. The optimum temperature for germination is 20–25°C and the germination rate declines below 15°C or above 35°C. It tolerates low temperatures, but if the temperature drops below 10°C flowering is reduced; it does not tolerate frost. Low temperatures and drought lead to flower and fruit abortion. Bottle gourd grows in a wide range of soil types but prefers well-aerated, fertile soils with pH 6–7.

Propagation and planting Bottle gourd is propagated by seed, which is often sown directly. Transplanting is possible if seed is scarce. As no commercial cultivars are available in Africa, farmers carefully select dried intact fruits for seed for the next crop. The seeds are often preserved in the intact fruits. For vegetable use, non-bitter types are selected by scratching the surface or chewing the leaves. The weight of 1000 seeds is about 150 g. Planting normally takes place with the onset of the rainy season. Seed dormancy often occurs. A heat treatment of 50°C for 7 days markedly increases the germination rate. Bottle gourd is often planted near the homestead. During the wet season it is often planted on mounds, in the dry season in depressions. It is sometimes intercropped with other vegetables and grain crops, especially pumpkin. Per hole 2–3 seeds are sown, at a spacing of 1 m in the row and 2 m between rows. Weak or diseased seedlings are thinned out 3–4 weeks after sowing, leaving one plant per hole. Spontaneous plants in fields are often retained. In cattle-herding communities such as the Maasai of Kenya, bottle gourd arises spontaneously along the fences of cattle enclosures where there is ample manure and enough moisture. Plants with large elongated fruits can occasionally be found on fences in abandoned homesteads. In Asia special vegetable cultivars are commercially grown on stakes or trellises, using the same cultural practices as for cucumber.

Management Bottle gourd has a good ability to suppress weed. It has an extensive but shallow root system and soil tillage should be minimized during the fruiting stage. Manual weeding around the base of the plant is recommended. For continuous growth, irrigation is needed in the dry season. In some communities people use an old clay pot half buried next to the plant base for irrigation. The container is filled with water and covered with a half bottle gourd serving as a lid. The water gradually oozes out to the roots. Water is added once or twice a week. Bottle gourd responds well to fertilizer. When available, ample manure is applied at planting. A chemical fertilizer NPK 10–10–20 at a rate of 500 kg/ha or 100 g per plant may be applied. Fruit size largely depends on the position of the fruit on the branch, the amount of rain, and damage by pests, whereas the fruit shape is largely determined by the cultivar. The shape can be manipulated by measures such as placing young fruits upright on a flat ground to obtain a gourd with a flat bottom, tying a string around the neck, or by hanging the fruits

straight or curbed on a fence. To obtain extra large fruits for use as container, often only a single fruit is left per plant.

Diseases and pests Major diseases of bottle gourd are anthracnose (*Colletotrichum lagenarium*) during the wet months and powdery mildew (*Erysiphe cichoracearum* and *Sphaerotheca fuliginea*) during the dry season. *Sclerotium* basal stem rot, fusarium wilt (*Fusarium oxysporum* f.sp. *lagenariae*) may attack the crop. Removal of infected leaves and good cultivation management are recommended to prevent disease build-up. Cultivars differ in resistance. The roots are susceptible to *Meloidogyne* root-knot nematodes. Cucurbit leaf beetles (*Chrysomelidae*) are common pests. They make circular holes in the leaves and damage the flowers. Blister beetles (*Coryna apicicornis*) eat the flower petals.

Harvesting For use as a vegetable, fruit harvesting starts three months after sowing. Young fruits of all ages are edible and may be picked, including the ovary of the flower. Continuous picking of young fruits prolongs crop duration and as many as 20 pickings may be possible. Fruits are best harvested with a sharp knife, leaving about 5 cm stalk on the fruit. Leaves are picked from 2-month-old plants onwards.
For seed production fruits are harvested when fully mature. Fruits are mature when the shell hardens and outer and inner layers start to yellow. This stage can be determined by scratching the fruit thinly to expose the inner yellow part. For use as containers, fruits are permitted to mature completely on the plant.

Yield A yield of 25 t/ha of fruits weighing 0.5–2 kg is considered a good yield in South-East Asia. One to more than 30 fruits may be harvested from one plant depending on the cultivar and growing conditions.

Handling after harvest Young fruits should be consumed within 2 weeks after harvest. Longer storage causes rapid loss of water, leading to loss of hairs and shine of the fruit surface.
For container use, seeds and pulp have to be removed. The fruits can be stored for a long time intact in a dry place. To clean the shells, the fruits may be buried in the soil for a few weeks or soaked in water before the skin is polished to get a clean surface. To remove the pulp, the fruits are soaked in water and the inside is stirred with a stick or they are filled with small stones and shaken. The tough rind of 1–13 mm thickness remains, and is dried well and cleaned further before use.
The oil is extracted from the seeds by first roasting and grinding them followed by boiling. This process frees the oil which floats to the surface of the water and is skimmed off.

Genetic resources In Africa local farmers maintain a large number of cultivars. The International Plant Genetic Resources Institute (IPGRI) and the Kenya Resource Centre for Indigenous Knowledge (KENRIK) of the National Museums of Kenya have collected and maintain hundreds of Kenyan landraces in the Gene Bank of Kenya. Of these, 30 local cultivars were described. Some are demonstrated in the field of the Botanic Garden of the National Museums. Bottle gourd accessions are available in genebanks in Benin, Cameroon, Ethiopia, Ghana, Kenya, Nigeria, Senegal, South Africa, Sudan, Tanzania, Zambia and Zimbabwe. Genetic erosion in local cultivars is taking place.

Breeding Fruit shape is strongly genetically determined, but fruit shape and size are also environmentally influenced. Bitter is a dominant character over sweet, with a 3:1 ratio. In Kenya, hand pollination showed that local cultivars cross easily and that crosses with the wild relative *Lagenaria sphaerica* (Sond.) Naudin are 40% successful. The interspecific hybrids show strong lateral stem development. Possibly natural hybrids do not occur because female flowers mostly abort and male flowers have less than 1% pollen viability. Improved cultivars of bottle gourd as a vegetable are available from seed companies in India, China, Taiwan, Japan, the Philippines and Thailand.

Prospects The bottle gourd is deeply integrated in many African cultures, a guarantee for the maintenance of the huge diversity, but little information has been documented. As a fruit vegetable it is expected to increase in popularity when commercial cultivars become available. Its popularity as a producer of calabashes seems lasting. The multipurpose uses of the calabash mean it has good commercial prospects. Research and breeding work is expected to lead to improved cultivars including hybrids, with the possibility of built-in disease resistances and of fruit shapes and sizes according to the use required.

Major references Darekar, K.S., Mhase, N.L. & Shelke, S.S., 1989; Decker-Walters, D., Staub, J., López-Sesé, A. & Nakata, E., 2001; Heiser, C.B., 1979; Jeffrey, C., 1967; Maundu, P.M., Ngugi, G.W. & Kabuye, C.H.S., 1999; Richardson, J.B., 1972; Schippers, R.R., 2002a;

Widjaja, E.A. & Reyes, M.E.C., 1993.

Other references Badade, D.S., Warade, S.D. & Gaikwat, S.K., 2001; Hossain, M.A., Sharfuddin, A.F.M., Mondal, M.F. & Aditya, D.K., 1990; Hurst, E., 1942; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Pammel, L.H., 1911; Williamson, J., 1955.

Sources of illustration Widjaja, E.A. & Reyes, M.E.C., 1993.

Authors Y. Morimoto & B. Mvere

LAGENARIA SPHAERICA (Sond.) Naudin

Protologue Ann. Sc. nat. Bot., sér. 5, 5: 99 (1866).

Family Cucurbitaceae

Chromosome number $2n = 22$

Synonyms *Lagenaria mascarena* Naudin (1862), *Sphaerosicyos sphaericus* (Sond.) Cogn. (1881).

Vernacular names Wild bottle gourd (En).

Origin and geographic distribution *Lagenaria sphaerica* occurs from Somalia through East Africa and eastern DR Congo to South Africa; it is also found in the Comoros and Madagascar.

Uses Leaves are collected in the wild and used as a vegetable in Malawi and Zimbabwe; they are non-bitter. Young fruits are also eaten as a vegetable in Zimbabwe. Mature fruits are poisonous, bitter and release strong-smelling volatile compounds. Fruits are used as a soap substitute.

An extract of the boiled roots is used as an internal medicine for gonorrhoea and to treat wounds in DR Congo, while an infusion from the fruits and leaves is used as a liniment to treat infections of the umbilical cord. The seeds are used in a veterinary anthelminthic. A root or leaf infusion is used by Zulu people to cure stomach-ache. Leaves and fruits are used as a medicine for chickenpox in western Kenya. Mature fruits are marketed in South Africa for unspecified medicinal use. The Kamba of Kenya use the fruits as poison for cockroaches and rats. A case of lethal human poisoning has been reported from South Africa. The fruits are used as footballs by children. *Lagenaria sphaerica* is grown as an ornamental garden plant.

Properties Cucurbitacins B and D have been isolated from the fruits and roots, with traces of other cucurbitacins in the fruits. The fruits contain saponin. The seeds are rich in oil.

Botany Dioecious, perennial, prostrate or scandent herb; stem annual, 10 m or more long, with proximally 2-fid tendrils. Leaves alternate, simple; petiole 1–12 cm long; blade broadly ovate, shallowly to deeply palmately 5-lobed, 5–19 cm × 4–22 cm, cordate at base. Flowers unisexual, regular, 5-merous, large, fragrant, hypanthium obconic below, expanded above, sepals 3–6 mm × 1.8–2.5 mm, petals obovate, 2.5–5.5 cm × 2–4.5 cm, white with green veins; male flowers in a raceme with peduncle up to 20 cm long, rarely solitary, pedicel up to 5 cm long, stamens 3, free; female flowers solitary, with peduncle up to 8.5 cm long, ovary inferior, ellipsoid, densely tomentose. Fruit a subglobose berry 7–11 cm × 6–10 cm, smooth, deep green with paler spots and patches; fruit-stalk 2.5–10 cm long, expanded at apex. Seeds oblong, compressed, 8.5–11.5 mm × 5–6 mm × 2–2.5 mm, faces with 2 submarginal ridges.

Flowers of *Lagenaria sphaerica* open around 7:00 a.m. and close in the afternoon. Bees and butterflies are the main pollinators.

Ecology *Lagenaria sphaerica* is frequently encountered in riverine forest and thickets. It is also found in disturbed vegetation, e.g. in abandoned fields and along roadsides. It occurs from sea-level up to 1700 m altitude, even up to 2700 m in Central Africa.

Genetic resources and breeding Hybrids between *Lagenaria sphaerica* and *Lagenaria siceraria* (Molina) Standl. (bottle gourd) are found in cultivation in eastern Africa. However, the hybrid is sterile: female flowers abort and male flowers have poor pollen viability. The possibility of transfer of desirable traits to *Lagenaria siceraria* still requires investigation. Resistance to powdery mildew (*Sphaerotheca fuliginea*) has been identified in some wild plants of *Lagenaria sphaerica*.

Prospects Unlike many other cucurbit species, interest in *Lagenaria sphaerica* appears to be limited to tropical countries. The main interest lies in its potential as a source of resistance genes for improvement of the bottle gourd.

Major references Jeffrey, C., 1978; Keraudren-Aymonin, M., 1975; Meeuse, A.D.J., 1962; Schippers, R.R., 2000; Williamson, J., 1955.

Other references Jeffrey, C., 1980; Watt, J.M. & Breyer-Brandwijk, M.G., 1962.

Authors C.H. Bosch

LAPORTEA OVALIFOLIA (Schumach.) Chew

Protologue Gard. Bull. Sing. 21: 201 (1965).
Family Urticaceae
Synonyms *Fleurya podocarpa* Wedd. (1869), *Fleurya ovalifolia* (Schumach.) Dandy (1952).
Vernacular names Mpupu (Sw).
Origin and geographic distribution *Laportea ovalifolia* is widespread in tropical Africa from Sierra Leone to southern Sudan and south to Angola and Tanzania. Further south it is obviously rare with a single specimen collected in Zimbabwe.
Uses Leaves of *Laportea ovalifolia* are eaten cooked as a vegetable in Cameroon, DR Congo, Kenya and Tanzania. In Tanzania chopped and boiled young leaves are often mixed with beans or peas and served with a staple food. Although they have a mild taste, they are eaten in small amounts.
In Nigeria the leaves are used as a haemostatic on cuts and wounds and as an anti-irritant, whereas the fruit is used as a poison antidote. In Gabon cooked leaves are eaten as a remedy for stomach-ache and cooked with peanuts they are given to pregnant women. In Cameroon the fresh leaves are used to relieve headache. In DR Congo the leaves are used as a diuretic, as a cure for blenorrhoea and chest problems and as a fish poison. In Tanzania an infusion prepared by pounding and soaking leaves in water is taken to help deliver the placenta after childbirth, and an infusion made by boiling roots in water is taken to prevent excessive menstrual bleeding. In Gabon *Laportea ovalifolia* is used during initiation rituals.
Properties The taste of the young leaves is said to be mild. No data have been published on nutritive value or chemical composition, but they are probably similar to those of *Laportea aestuans* (L.) Gaudich., which is also eaten as a vegetable, but is better known as a fibre plant and for its uses in traditional medicine. Fresh leaves of the latter species contain per 100 g edible portion: water 80 g, energy 222 kJ (53 kcal), protein 5.8 g, fat 4.0 g, carbohydrate 10.0 g, fibre 3.0 g, Ca 440 mg, P 114 mg, Fe 1.5 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968).
Botany Monoecious, stoloniferous, perennial herb, with scattered stinging hairs; main stem often prostrate with erect shoots up to 2 m tall. Leaves alternate, simple; stipules fused almost to the apex, up to 1 cm long; petiole 5–10 cm long; blade ovate, 8–10 cm × 4–6 cm, base subcordate to rounded, apex acute to acuminate, margin crenate to serrate. Inflorescence unisexual; male inflorescence paniculate, arising from stolons, rarely axillary on the erect stems, up to 50 cm long; female inflorescence shortly racemose or paniculate, mostly axillary on the erect stems. Flowers unisexual, pedicellate, perianth up to 2 mm long; male flowers with 5 tepals and stamens; female flowers with 4 tepals and superior 1-celled ovary, stigma 3-branched. Fruit an ovoid achene up to 3 mm long.
Laportea comprises 22 species, the majority of them in Africa and Madagascar. Several species are used as vegetables, for their fibre and in traditional medicine.
Ecology *Laportea ovalifolia* occurs in forest, also in swamp forest and along streams, at 900–2000 m altitude. It can be very common in disturbed habitats such as cleared forest patches, fallow land and close to habitation.
Management *Laportea ovalifolia* is a noxious weed in perennial crops such as cacao, oil palm and bananas.
Genetic resources and breeding *Laportea ovalifolia* has a wide distribution and is often very common in disturbed habitats. Therefore it is not at risk of genetic erosion.
Prospects *Laportea ovalifolia* will continue to be of local use as a vegetable. Some other *Laportea* species are obvious candidates for pharmacological investigations, and if the results are promising, attention may be drawn to *Laportea ovalifolia* as well.
Major references Burkill, H.M., 2000; Friis, I., 1989a; Ruffo, C.K., Birnie, A. & Tengnäs, B., 2002.
Other references Chew, W.L., 1967; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; van Valkenburg, J.L.C.H., 2001.
Authors C.H. Bosch

LASIMORPHA SENEGALENSIS Schott

Protologue Bonplandia 5(8): 127 (1857).
Family Araceae
Chromosome number $2n = 26$
Synonyms *Lasimorpha afzelii* Schott (1858), *Cyrtosperma senegalense* (Schott) Engl. (1879).
Vernacular names Swamp arum (En). Grand arum du Sénégal, taro des marais, maïs des esprits (Fr).
Origin and geographic distribution *Lasimorpha senegalensis* occurs from Senegal to Chad, Central African Republic, DR Congo and Angola. It is not known from East Africa.
Uses The young leaves of *Lasimorpha sene-*

galensis are eaten as a vegetable in Gabon; they are collected from the wild. In Sierra Leone the young leaf is eaten as a famine food, and as an ingredient of palaver sauce.

In Congo the leaves are given to women during childbirth to accelerate delivery. In Côte d'Ivoire the leaf sap has been taken orally against hiccups. In Gabon the rhizomes are used to treat ulcers. A decoction is analgesic and sedative. In Congo it is taken as cough cure (one teaspoon), and in larger doses to treat nervousness and agitation. In southern Nigeria the fruits are an ingredient of remedies for gonorrhoea and dysentery. In Sierra Leone and Gabon salt is extracted from the ashes of burnt plants. In some parts of Gabon the leaves are used to wrap dumplings of tapioca flour.

Botany Large herb with a short and thick rhizome, vigorously stoloniferous. Leaves in a tuft, simple; petiole erect, spiny, 0.5–1(–2) m long; blade sagittate, 20–50(–100) cm × 15–30(–40) cm, basal lobes acuminate. Inflorescence a cylindrical, purplish spadix up to 12 cm long, enclosed by a spathe up to 45 cm long, spathe greenish outside, whitish with purple streaks inside; peduncle 1–1.5(–2.5) m tall, spiny, solitary, emerging from the leaves. Flowers bisexual, sessile and tightly packed on the spadix, 4(–5)-merous; tepals free; stamens free or connate; ovary superior, 1-celled. Fruit an irregularly globose berry c. 1.5 cm long, red, 1–4-seeded. Seeds strongly curved, brown, warty.

Lasimorpha comprises a single species and is the only African representative of subfamily *Lasioideae* consisting of 10 genera. It seems most closely related to *Cyrtosperma* from Asia.

Ecology *Lasimorpha senegalensis* occurs in swamp forest, along streams, in ditches and ponds, often very abundant.

Genetic resources and breeding *Lasimorpha senegalensis* is quite common in swampy areas, where it forms large populations due to its strong development of underground suckers. No collections of genetic resources are known. The species is not in danger of genetic erosion.

Prospects *Lasimorpha senegalensis* does not seem to have great potential as a vegetable. The possibilities for its use as an indoor pot plant in temperate climates or as garden pond ornamental in warmer climates seem promising.

Major references Burkill, H.M., 1985; Raponda-Walker, A., 1953; Raponda-Walker, A. & Sillans, R., 1961.

Other references Boos, J., 2003; Bouquet, A., 1969; Bouquet, A. & Debray, M., 1974; Dalziel, J.M., 1937; Mayo, S.J., Bogner, J. & Boyce, P.C., 1997; Vanden Berghen, C., 1988.

Authors W.J. van der Burg

LAUNAEA CORNUTA (Hochst. ex Oliv. & Hiern) C.Jeffrey

Protologue Kew Bull. 18: 468 (1966).

Family Asteraceae (Compositae)

Chromosome number $2n = 10$

Synonyms *Sonchus cornutus* Hochst. ex Oliv. & Hiern (1877), *Sonchus exauriculatus* (Oliv. & Hiern) O. Hoffm. (1895).

Vernacular names Bitter lettuce (En). Laitue amère (Fr). Mtsunga (Sw).

Origin and geographic distribution *Launaea cornuta* is distributed from Nigeria east to Djibouti and Somalia and south to Zimbabwe and Mozambique. It is mainly used as a vegetable in East Africa.

Uses The leaves of bitter lettuce are cooked and eaten with amaranth, pumpkin or cowpea leaves. When there are no other vegetables present to mix bitter lettuce with, people replace the cooking water to reduce the bitter taste. Bitter lettuce is an important vegetable for the Giriama, Kamba, Taita and other coastal tribes in Kenya and Somalia, and also for the Sambaa people of Tanzania's Usambara Mountains. In these areas, especially amongst the Giriama people, it has several ceremonial uses. Coastal people believe that it can prevent and cure malaria, whereas people with stomach problems or ulcers should not eat it. The rhizomes are used in Malawi and Tanzania as a cure against venereal diseases and hook-

Launaea cornuta – wild

worm. In Kenya and Tanzania the roots are chewed in case of swollen testicles, they are boiled to make a drink against cough and typhus, and an infusion of the root is used as an eye wash and against earache. In Kenya a decoction of the whole plant is used externally to treat measles. In Sudan it is used to give a bitter taste to beer. The leaves are fed to cattle in Tanzania to increase the milk yield.

Production and international trade The leaves are mostly collected from the wild, but some cultivation takes place in Ethiopia, Somalia, Kenya and Tanzania, mainly in home gardens. Of late, production in a peri-urban environment for city markets is emerging. This vegetable is frequently found on local markets in the coastal zones of Kenya and Tanzania, and also in the Usambara Mountains, but no cross-border trade is known to take place.

Properties The nutritional composition of young *Launaea cornuta* leaves is per 100 g edible portion: water 86.8 g, protein 3.9 g, fat 0.9 g, carbohydrate 4.5 g, Ca 214 mg, P 13.2 mg, Fe 7.2 mg, ascorbic acid 18.7 mg (Ndossi, G.D. & Sreeramulu, N., 1991). The leaves contain a milky white fluid and are generally bitter in taste, although there are some selections that are referred to as sweet.

Adulterations and substitutes The leaves of bitter lettuce can be replaced by *Sonchus oleraceus* L. or *Launaea taraxacifolia* (Willd.) Amin ex C.Jeffrey leaves.

Description Perennial herb up to 100(–150) cm tall, with creeping root system; stem erect, hollow, slightly glaucous. Leaves at base of plant in a rosette, alternate on stem, without stipules, sessile, obovate or broadly spatulate to narrowly elliptical or lanceolate in outline, 2–25 cm × 0.5–8 cm, simple to deeply pinnatifid, lower leaves tapering at base, higher ones auriculate, toothed. Inflorescence a 15–27-flowered head arranged in a divaricately branched, bracteate synflorescence; peduncle 0.5–2.5 cm long, often with stalked glands; involucre with imbricate outer bracts and a single row of longer, linear-lanceolate inner bracts 8–13 mm long. Flowers all ligulate; corolla with tube c. 0.5 cm long and ligule c. 1 cm long, pale yellow; stamens 5, anthers united into a tube, blackish yellow; ovary inferior, 1-celled, style 2-branched. Fruit a cylindrical to fusiform achene 2.5–4.5 mm long, ribbed, crowned by white pappus hairs 5–7 mm long.

Other botanical information *Launaea* comprises about 55 species and occurs in Africa and south-western Asia, but a single species (*Launaea intybacea* (Jacq.) Beauverd) has been introduced and naturalized in the Caribbean region and Central America. Northern and eastern Africa are particularly rich in species. *Launaea* is placed in tribe *Lactuceae* subtribe *Sonchinae*, together with e.g. *Reichardia* and *Sonchus*.

Growth and development Seed germinates within a few days. After emergence, the young plant develops a rosette of leaves. A leafy flowering stalk is soon formed. In Kenya and Tanzania flowering is year-round. Plants are self-fertile. After fruiting new growth develops from the base of the stem and from the root. Even during the dry season the plants form new rosette leaves and they keep producing new shoots from the roots for several years.

Ecology *Launaea cornuta* grows in disturbed localities such as roadsides or as a troublesome weed in perennial plantations of trees or shrubs. It can also be found in grassland. It is most common in the hot lowland coastal zones of East Africa and near the great lakes and less common in highland areas up to 2300 m altitude. It prefers sandy soils in relatively dry localities, but also grows on loam and even black cotton soils.

Propagation and planting Bitter lettuce can be propagated vegetatively. People may select plants from the wild that are sweet or only slightly bitter, and plant these in their garden. Some gardeners split the roots from carefully selected plants to produce a number of new plantlets and thus create a uniform crop of the desirable type.

Management Care should be taken to prevent bitter lettuce spreading as a weed.

Harvesting People select young, large rosette leaves because older leaves and small stem leaves are usually too bitter.

Genetic resources *Launaea cornuta* is a common weed not threatened by genetic erosion. Selections of less bitter types, made by farmers, are readily available.

Prospects *Launaea cornuta* is quite a popular wild vegetable in East Africa. Domestication is taking place locally. Bitter lettuce merits attention in agronomic research and breeding.

Major references Agnew, A.D.Q. & Agnew, S., 1994; Burkill, H.M., 1985; Kilian, N., 1997; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Maundu, P.M., Ngugi, G.W. & Kabuye, C.H.S., 1999; Schippers, R.R., 2002a.

Other references Beentje, H.J., 2000; Kokwaro, J.O., 1993; Ndossi, G.D. & Sreeramulu, N., 1991; Pope, G.V., 1992.

Authors R.R. Schippers

LAUNAEA TARAXACIFOLIA (Willd.) Amin ex C.Jeffrey

Protologue Kew Bull. 18: 474 (1966).

Family Asteraceae (Compositae)

Chromosome number $2n = 18$

Synonyms *Sonchus taraxacifolius* Willd. (1804), *Lactuca taraxacifolia* (Willd.) Schumach. ex Hornem. (1819).

Vernacular names Yanrin, African lettuce, wild lettuce (En). Langue de vache (Fr).

Origin and geographic distribution *Launaea taraxacifolia* occurs from Senegal east to Ethiopia and Tanzania. The Ethiopian highlands have been suggested as the place of origin, from where it was introduced elsewhere and spread as a weed. *Launaea taraxacifolia* has been domesticated as a leafy vegetable in Nigeria, and is also cultivated locally in Senegal and Benin.

Uses Yanrin leaves are eaten fresh as a salad or cooked in soups or sauces. Amongst the Yoruba people in Nigeria soup made of yanrin leaves, called 'efo yanrin' is popular. Wild yanrin has hard leaves that are very bitter, whereas leaves of cultivated types are more tender and less bitter. In northern Nigeria plants are fed to nursing cattle to increase milk production, and yanrin is given to livestock to induce multiple births. A leaf extract mixed with breast-milk of a nursing mother is administered medicinally to cure partial blindness resulting from snake spit. In Benin it is used as a febrifuge. In Ghana the leaves are rubbed on the limbs of backward children to induce them to walk. In Nigeria the plant is sometimes burnt for its ashes, which are used as vegetable salt.

Launaea taraxacifolia – wild and planted

Production and international trade Yanrin is mostly collected from the wild and only cultivated to a limited extent for home use and for local markets. Bundles of fresh yanrin leaves soaked in water and cooked leaves packed in balls can be found at local Nigerian markets. There are no records on production and trade.

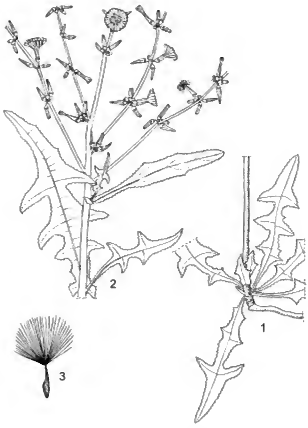
Properties The composition of yanrin leaves per 100 g edible portion is: water 84.3 g, energy 184 kJ (44 kcal), protein 3.2 g, fat 0.8 g, carbohydrate 8.3 g, fibre 2.0 g, Ca 326 mg, P 58 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968).

In tests with animals in Ghana, leaves of *Launaea taraxacifolia* showed a cholesterol-lowering effect.

Description Perennial herb up to 150 cm tall, with creeping root system; stem erect, often woody at base. Leaves at base of plant in a rosette, alternate on stem, without stipules, sessile, spatulate to elliptical in outline, 4–20 cm × (0.5–)1–9 cm, simple to pinnatifid, lower leaves tapering at base, higher ones auriculate, toothed. Inflorescence a 12–22-flowered head arranged in a branched synflorescence; peduncle up to 1 cm long; involucre with imbricate outer bracts and a single row of 5 longer, linear-lanceolate inner bracts 8–12 mm long. Flowers all ligulate; corolla with tube c. 5 mm long and ligule 6–7 mm long, golden yellow; stamens 5, anthers united into a tube; ovary inferior, 1-celled, style 2-branched. Fruit a cylindrical to fusiform achene 3–5 mm long, slightly beaked, ribbed, crowned by white pappus hairs 5–8 mm long.

Other botanical information *Launaea* comprises about 55 species and occurs in Africa and south-western Asia, but a single species (*Launaea intybacea* (Jacq.) Beauverd) has been introduced and naturalized in the Caribbean region and Central America. Particularly northern and eastern Africa is rich in species. *Launaea* is placed in tribe *Lactuceae* subtribe *Sonchinae*, together with e.g. *Reichardia* and *Sonchus*.

Growth and development After the seeds have germinated, the young plants initially form a rosette of leaves. Thick roots develop later on in the season. In cultivation these are left in the ground during the dry season. From the onset of the rainy season, new rosettes are formed along the roots. The rosette leaves are most liked as a vegetable in the early stages of growth when they are not yet very bitter. A flowering shoot develops from the rosette, and the stem leaves are less appreciated because



Launaea taraxacifolia – 1, basal part of plant; 2, flowering branch; 3, fruit.
Redrawn and adapted by Iskak Syamsudin

they are very bitter, especially as they get older. Seed can be collected about 3–4 months after sowing. The pappus attached to the fruits allows their dispersal by wind. The germination percentage is low, which is compensated for by the production of thousands of seeds per plant.

Ecology *Launaea taraxacifolia* is frequently found in disturbed localities in open savanna vegetation. Only in Ethiopia is it recorded from undisturbed localities in grassland with scattered trees at 1300–1700 m altitude. It seems to prefer slightly humid conditions. *Launaea taraxacifolia* is often referred to as a dry season vegetable. It tolerates drought rather well and can also grow on poor soils with a low water table. It prefers altitudes of 600–1000 m rather than the lowland regions. The plants need a sunny place and do not tolerate shade.

Propagation and planting Removing the pappus from the fruits is a cumbersome process and since the seed germination percentage is rather low, vegetative propagation using the roots is common. Roots are cut in pieces of about 10 cm length and these are planted horizontally and entirely covered with soil; 30–50 cuttings may be planted in a bed of 10 m^2.

Management Yanrin does not need much management because of its low water requirement. Once the plant has developed and starts producing leaves, regular harvesting is recommended. Little is known about the plant's response to manure and fertilizer applications. Organic manure encourages production of quality leaves under irrigation. A yanrin crop should be kept under control because it can easily become a persistent weed with its perennial root system.

Diseases and pests Grey mould (*Colletotrichum* sp.) can kill fully-grown plants, with devastating effect especially when the crop is grown in the shade.

Harvesting Young large leaves from the rosettes are picked. Consistent harvesting of leaves promotes the production of new leaves and delays the initiation of flowering stems. As soon as these develop, production drops and the leaf size and quality deteriorate.

Yield From a well-managed bed of 10 m^2 one may expect 15–20 harvests during a 6–7 month period, with a total yield of 20 kg. The seed yield is 0.3–0.6 kg per bed (before cleaning).

Handling after harvest After the leaves have been harvested, they are either used fresh or they are boiled and rolled into balls for sale at the market.

Genetic resources A limited number of germplasm accessions (root cuttings) collected in 1999 were established in the CENRAD live genebank in Nigeria for evaluation and observation. As long as no improved cultivars are available, there is no danger of genetic erosion of farmers' selections. Sampling and research of the putatively wild populations in Ethiopia may reveal the origin and genetic variability of this vegetable.

Breeding There is an urgent need for breeding and selection. Other than some farmers making their own selections, no breeding work is currently being done on yanrin.

Prospects Yanrin is one of the traditional leafy vegetables that is important especially in Nigeria. Selection of plants with tender leaves of low bitterness would increase its popularity. Agronomic research is needed to further its domestication. Research into its cultivation as a vegetable and into the medicinal properties of this plant is warranted.

Major references Adebisi, A.A. & Ladipo, D.O., 2000b; Burkill, H.M., 1985; Kilian, N., 1997; Leung, W.-T.W., Busson, F. & Jardin, C.,

1968; Schippers, R.R., 2000; van der Zon, A.P.M. & Grubben, G.J.H., 1976; van Epenhuijsen, C.W., 1974.

Other references Beentje, H.J., 2000.

Sources of illustration Berhaut, J., 1974; Busson, F., 1965.

Authors A.A. Adebisi

LEMUROPISUM EDULE H.Perrier

Protologue Bull. Soc. Bot. France 85: 494 (1939).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Vernacular names Tara nut (En). Tara (Fr).

Origin and geographic distribution *Lemuropisum edule* is restricted to the most southern part of Madagascar with two disjunct populations some 60 km apart. One population is known near Itampolo and the second around Lake Tsimanampetsotsa.

Uses The immature fruits of *Lemuropisum edule* provide a local food. Seeds are eaten raw, after discarding the brittle testa. They are apparently not used in cooking. Goats browse the shrubs when there is little else to eat; they also eat the seeds.

Properties The flavour of green seeds of *Lemuropisum edule* is reminiscent of fresh garden peas. The cotyledons are agreeably sweet with a cashew-like flavour, smooth consistency and a flexible, rather plastic texture. The seeds contain 38–43% available carbohydrates, 26–32% unavailable carbohydrates, 14–26% protein and 6–9% fat. However, the ingestion of 100 g kernels (c. 85 raw seeds) may inhibit human production of chymotrypsin and cause digestive upsets; this may be reduced by cooking or roasting. Per 100 g dry matter, seeds contain 1–5 g trans-3-hydroxy-L-proline, mature leaves 1–2 g. Hydroxyproline showed potent antifeedant activity against larvae of *Spodoptera* spp. It is cytotoxic to human fibroblast cells. A second potentially toxic amino acid, azetidine-2-carboxylic acid, has been identified in the seed. Consumption of small quantities is unlikely to cause poisoning, but the long-term physiological effects still need to be assessed.

Botany Shrub up to 6 m tall, many-stemmed and much branched, lateral shoots terminating in rigid spines. Leaves alternate, in tight clusters, paripinnate with 1–4 pairs of leaflets; stipules small, caducous; leaflets ovate to orbicular, 3.5–6 mm long. Inflorescence an axillary raceme. Flowers bisexual, almost regular, 5-merous; calyx with leathery lobes; petals free, clawed, the upper ones slightly larger, white, tinged yellow; stamens 10, free; ovary superior, sessile, 1-celled, style slender, stigma punctate. Fruit a pendent, compressed-cylindrical pod 20–30 cm × 2 cm, constricted between the seeds, densely grey pubescent, spirally dehiscent with 2 valves, 6–16-seeded. Seeds ovoid-reniform, c. 2.5 cm × 1.5 cm, seedcoat cream-white, thin and brittle.

Lemuropisum comprises a single species and is closely related to *Colvillea* and *Delonix*. Two growth forms have been distinguished: a spreading shrub and a less common, compact shrub with erect branches.

Ecology *Lemuropisum edule* appears to be confined to an exposed seaward-facing rocky limestone escarpment and sandy soils immediately below them, at 15–100 m altitude. The rainfall in the area is bimodal and very erratic, with an annual average of less than 400 mm. The average temperatures are 27°C in summer and 20°C in winter. In cultivation the plant prefers alkaline soils.

Management *Lemuropisum edule* is not cultivated in Madagascar nor sold on local markets. The species has been under investigation as a potential crop in western Australia. Seeds need to be stored at low temperatures and low relative humidity. They can be sown in 20 cm long bags. Germination is rapid after soaking for 10 hours. Aerial growth is characteristically zigzag with rapid development of side branches, requiring plants to be well spaced in the nursery to prevent entanglement. Transplanting can be done after 3 months at a spacing of 4 m × 4 m.

Genetic resources and breeding The distribution of *Lemuropisum edule* is restricted and fragmented. The species is threatened by intensive grazing, especially in the main population site around Itampolo. It is therefore classified as endangered by IUCN.

Prospects *Lemuropisum edule* has potential as a vegetable for arid areas if toxicity barriers are overcome. It has further potential for windbreaks and hedges. A survey of the extent and the genetic variation of the natural populations and measures for its conservation are required. Other obvious steps are to establish provenance trials, to select high-yielding, toxin-free trees and to evaluate the two growth forms. The potential for micropropagation and production in arid regions in the tropics needs

to be investigated, as well as its agronomic requirements.

Prolines are promising for treating excessive collagen production in humans and as inhibitors of tumours that require collagen for growth. *Lemuropisum edule* could provide a useful source of proline for research purposes.

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Other references Banks, H., 1997; Schatz, G.E., 2001.

Authors C.H. Bosch

LEPIDIUM SATIVUM L.

Protologue Sp. pl. 2: 644 (1753).

Family Brassicaceae (Cruciferae)

Chromosome number $2n$ = 16, 24, 36

Vernacular names Garden cress, peppergrass (En). Cresson alénois, cresson des jardins, cressonnette (Fr). Mastruço ordinário, agrião mouro (Po).

Origin and geographic distribution The exact origin of *Lepidium sativum* is unknown but is thought to be in Ethiopia and neighbouring countries or in western Asia. Domestication presumably took place in western Asia. Cultivation was already known from antiquity in Greece and Italy, possibly also in Egypt. At present it is cultivated all over the world, including most African countries, mostly on a small scale as a garden crop. It can also be found in the wild as an escape from cultivation, but it is not known whether it occurs anywhere truly wild.

Uses In many parts of the world seedlings of *Lepidium sativum* are used in salads because of their pungent taste. Whole fruits or seeds are used, fresh or dried, as a seasoning with a peppery flavour. Boiled seeds are consumed in drinks by Arabs, either ground in honey or as an infusion in hot milk. The seed oil can be used for illumination and soap making. In Ethiopia the seed and its oil are primarily used medicinally, but also as condiment and in baking, although the odour of the oil is not pleasant. A paste of the seeds with water is applied to chapped lips, and also against sunburn and other skin problems of humans and animals. The paste is also taken internally with honey to treat amoebic dysentery, and given to animals with stomach problems. The seeds are chewed to treat sore throat, cough, asthma and headache, and in large quantities to induce abortion. They are also applied externally as an insect repellent. In Mauritius pounded seeds in water are used to treat hiccough and stomach-ache. In India the seed oil, like mustard oil, is used to treat hiccough and intestinal problems. The pounded seeds are poulticed on the skin, and have a vesicant and soothing action on bruises and sprains. The seeds are also considered galactagogue, emmenagogue, laxative, tonic, diuretic and aphrodisiac. The mucilage of the germinating seeds allays the irritation of the intestines in dysentery and diarrhoea. The seeds are a panacea in medecine of the Maghreb. The aerial parts are used in the treatment of asthma, cough and bleeding piles. Leaves are mildly stimulant and diuretic, and useful in scorbutic diseases and liver complaints. The roots are used against syphilis. In Europe the herb is used to treat cough and constipation, as a diuretic and to improve the immune system.

Lepidium sativum is extensively used as a test organism in plant physiological studies, as an indicator organism to examine toxicity levels of environmental pollutants, and in experimental studies assessing diverse pathogens.

Properties The nutritional composition of fresh garden cress seedlings is per 100 g edible portion: water 89 g, energy 134 kJ (32 kcal), protein 2.6 g, fat 0.7 g, carbohydrate 5.5 g, fibre 1.1 g, Ca 81 mg, Mg 38 mg, P 76 mg, Fe 1.3 mg, Zn 0.23 mg, vitamin A 9300 IU, thiamin 0.08 mg, riboflavin 0.26 mg, niacin 1.0 mg, folate 80 µg, ascorbic acid 69 mg (USDA, 2002).

The stem and leaves of *Lepidium sativum* contain glucosinolates, the main component being glucotropaeolin (benzylglucosinolate). Upon steam distillation the herb yields about 0.1% of a colourless essential oil, with a characteristic pungent odour. The seeds yield about 25% of a yellowish-brown, semi-drying oil with a peculiar, disagreeable odour. The oil is rich in oleic, linoleic and uric acids, and also contains imidazole alkaloids. It has antioxidant properties.

The seedcoat of germinating seeds contains much mucilage, which has an allelopathic substance, lepidimoide. The effects of the germinating seeds were studied to determine the potential for slowing down the hydrolysis of starch to glucose in diabetic persons. The seeds significantly lowered the glycaemic response to a test meal. In the long term (21 days) treatment of diabetics with 15 g seeds/day, there

was a significant reduction in the levels of blood glucose at the end of study period. The ethanol extract of the seeds showed significant anti-inflammatory effects against carrageenan-induced rat paw oedema, at a dose of 500 mg/kg. The seed oil has a pronounced oestrogenic activity.
The antibacterial action of *Lepidium sativum* has been demonstrated in several tests. The extract of the fresh leaves showed strong antibacterial action against *Bacillus subtilis* and *Micrococcus pyogenes* var. *aureus*, but was less effective against *Escherichia coli*. The antibacterial action depends largely on the age of the plants used. An antiviral effect against the encephalitis virus Columbia SH was demonstrated in a test on mice. An extract of *Lepidium sativum* decreased the mutagenic effects of a number of pesticides, using *Salmonella typhimurium* strains as test organisms. The leaves showed significant teratologic effect in tests with rats.

Botany Erect annual herb up to 80 cm tall, more or less glaucous; stem terete or finely striate, profusely branched, glabrous. Leaves alternate, irregularly pinnate, up to 12 cm × 9 cm; petiole up to 4 cm long; leaflets 5–11, in outline ovate or obovate, pinnatisect, the ultimate lobes usually irregularly toothed, sparsely hairy above, glabrous below, leaflets of higher leaves gradually becoming linear, upper leaves usually simple and linear, sometimes lobed or with teeth. Inflorescence a terminal or axillary raceme 1–3 cm long, accrescent to 25 cm when fruiting. Flowers bisexual, regular, 4-merous; pedicel 1.5–4.5 mm long, ascending; sepals ovate, 1–2 mm long; petals spatulate with short claw, up to 3 mm long, white or pale pink; stamens 6, anthers usually purplish; ovary superior, flattened, apex emarginate, style up to 0.5 mm long, stigma capitate. Fruit a round or ovate, flattened silique 4–6 mm × 3–5.5 mm, pale green to yellowish, margins wing-like, apex emarginate, dehiscing by 2 valves, usually 2-seeded. Seeds ovoid, flattened, 2–3 mm long, pale brown to almost black. Seedling with epigeal germination; cotyledons 3-foliolate, leaflets spatulate, lateral ones smaller than central one.

Lepidium sativum – 1, flowering and fruiting stem; 2, basal leaf; 3, flower; 4, seed.
Source: PROSEA

Lepidium comprises about 150 species and is distributed worldwide. In tropical Africa 9 species can be found. Because of the great variability in leaf shape, fruit size and seed colour, many subclassifications of *Lepidium sativum* have been published, all of them however, without much practical value. For this cultivated species it would be more appropriate to distinguish cultivars. The life cycle of the plant is about 3 months. The flowers of *Lepidium sativum* are slightly protogynous and have a strong odour, attracting numerous insects that promote cross-pollination. In water, the seeds become covered in slime.

Ecology *Lepidium sativum* thrives on any rich, light, moisture-retentive soil, but grows best on moist loams. It can be grown at all elevations throughout the year, but in tropical regions it grows best in the cool season. It is rather drought resistant. In tropical Africa it is grown at 750–2900 m altitude, preferring cooler localities at around 2400 m altitude.

Management *Lepidium sativum* is usually grown as a garden crop or, for example in Ethiopia, in fields mixed with tef or flax. For sprout production, the seeds are sown thickly in rows, covered lightly with soil or not. About 10 days after germination the seedlings can be harvested. Plants can also be thinned if larger plants are preferred. In Europe, the sprouts are sold directly in the small boxes in which they germinated. For seed production, a few plants are left till the seeds are fully mature. The plants are then pulled up, dried and threshed. Serious diseases and pests are not

known, but some fungal and viral infections have been recorded, as well as susceptibility to nematodes.

Genetic resources and breeding *Lepidium sativum* is widely cultivated and shows quite some variability. It does not seem liable to genetic erosion.

Prospects *Lepidium sativum* will remain a minor vegetable, used widely but in small quantities. The glucosinolates present are known to display several interesting pharmacological activities, which merit further research. In addition, the mucilage from the seeds shows an interesting effect on the rate of starch hydrolysis, which might be promising for the treatment of non-insulin dependent diabetes.

Major references Brotonegoro, S. & Wiharti, W., 2001; Burkill, H.M., 1985; Jansen, P.C.M., 1981; Jonsell, B., 1982b; Schippers, R.R., 2000.

Other references Adam, S.E.I., 1999; Ashebir, M. & Ashenafi, M., 1999; Fleming, T. (Editor), 1998; Gurib-Fakim, A., Guého, J. & Bissoondoyal, M.D., 1995; Jonsell, B., 2000; Kalaycioglu, A., Oner, C. & Erdem, G., 1997; Nath, D., Sethi, N., Singh, R.K. & Jain, A.K., 1992; Patole, A.P., Agte, V.V. & Phadnis, M.C., 1998; Small, E., 1997; USDA, 2002a.

Sources of illustration Brotonegoro, S. & Wiharti, W., 2001.

Authors P.C.M. Jansen

Based on PROSEA 12(2): Medicinal plants 2.

LEPISTEMON OWARIENSE (P.Beauv.) Hallier f.

Protologue Ann. Mus. Congo, Bot., sér. 4: 112 (1903).

Family Convolvulaceae

Synonyms *Ipomoea owariensis* P.Beauv. (1816), *Lepistemon africanum* Oliv. (1878).

Origin and geographic distribution *Lepistemon owariense* is widely distributed in tropical Africa, where it occurs in all regions.

Uses In south-eastern Ghana the leaves of *Lepistemon owariense* are collected from the wild and eaten as a cooked vegetable.

Botany Climbing perennial herb with stem up to 3 m long, covered with appressed yellow-brown bristly hairs. Leaves alternate, simple; stipules absent; petiole up to 15 cm long, hairy; blade cordate-ovate, up to 16 cm × 16 cm, base deeply cordate, apex acute to emarginate, margin entire, shallowly lobed or coarsely dentate, pilose on both surfaces. Inflorescence an axillary, dense, sessile or shortly peduncled, many-flowered cyme. Flowers bisexual, regular, 5-merous; pedicel up to 2.5 cm long; sepals ovate to elliptical, c. 6 mm × 3.5 mm, usually hairy; corolla urceolate, up to 1.8 cm long, white, constricted at apex of tube, limb shortly lobed, up to 3 cm in diameter; stamens inserted at base of corolla tube, with basal part of filaments dilated into large concave scales arching over the ovary; ovary superior, glabrous to hairy, 2-celled, style very short, stigma 2-lobed. Fruit an ovoid-globose, leathery capsule c. 1.5 cm × 1.2 cm, covered with long yellow bristle-like hairs, indehiscent or bursting irregularly, 4-seeded. Seeds subglobose, c. 5 mm in diameter, grey-black, glabrous, shallowly pitted.

Lepistemon comprises about 10 species and is confined to the Old World tropics, with 2 species in Africa.

Ecology *Lepistemon owariense* occurs in lowland rainforest, riverine forest, thickets, savanna woodland, wasteland and as a weed in cultivated fields, from sea-level up to 1400 m altitude.

Genetic resources and breeding *Lepistemon owariense* is widespread and not in danger of genetic erosion.

Prospects *Lepistemon owariense* will remain a minor vegetable of local use only. Its nutritional composition needs investigation.

Major references Burkill, H.M., 1985; Gonçalves, M.L., 1987.

Other references Verdcourt, B., 1963.

Authors P.C.M. Jansen

LEPTADENIA HASTATA (Pers.) Decne.

Protologue DC., Prodr. 8: 551 (1844).

Family Asclepiadaceae (APG: Apocynaceae)

Synonyms *Cynanchum lanceolatum* Poir. (1811), *Cynanchum lancifolium* Schumach. & Thonn. (1827), *Leptadenia lancifolia* (Schumach. & Thonn.) Decne. (1838).

Origin and geographic distribution *Leptadenia hastata* is widely distributed in tropical Africa: from Mauritania and Senegal eastwards to Cameroon, Ethiopia, northern Kenya and to Uganda. In some locations, e.g. locally in Ethiopia, it is also cultivated.

Uses Everywhere in its distribution area, leaves, young shoots and flowers of *Leptadenia hastata* are eaten as a cooked vegetable and in soups. In Uganda chopped and boiled leaves are mixed with beans, pigeon peas or cowpeas. In many parts it is a famine food, but poor peo-

ple also eat this vegetable in normal times. In an interview on the preference for 14 wild herbaceous vegetables held in Burkina Faso in 1999, *Leptadenia hastata* ranked 3rd; its taste was considered good, and its tolerance of drought, insects and poor soil conditions as very good.

The plant is an important camel, goat and cattle fodder. Medicinally, *Leptadenia hastata* has many applications. The latex is applied on wounds and put in the nose against headache. Decoctions and macerations of roots and leaves are applied (alone or in combination with preparations of other plants) against abdominal complaints such as constipation, urethral discharge, gonorrhoea, stomachache and diarrhoea. In veterinary medicine the plant is used against colic in horses and cattle.

Properties Fresh leaves of *Leptadenia hastata* contain per 100 g: water 81 g, energy 226 kJ (54 kcal), protein 4.9 g, fat 0.2 g, carbohydrate 11.3 g, fibre 4.7 g, Ca 417 mg, P 94 mg, Fe 5.4 mg, vitamin A 4915 mg, thiamin 0.25 mg, riboflavin 0.35 mg, niacin 1.9 mg, ascorbic acid 78 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). The latex contains the triterpene lupeol and derivatives of it, which possess anti-inflammatory activity.

Botany Climbing, latex-containing herb, becoming woody at base, with strongly branched, finely pubescent stems becoming corky with age. Leaves opposite, simple; petiole 0.5–1.5 cm long; blade variable, usually ovate, 2.5–12.5 cm × 0.5–4 cm, base rounded to cordate, apex acuminate, margin entire, both sides puberulous, often glabrescent. Inflorescence umbellate, minutely tomentose in all parts, many-flowered; peduncle up to 1.5 cm long. Flowers bisexual, regular, 5-merous, yellowish, scented; pedicel up to 0.5 cm long; calyx lobed nearly to the base, lobes 2–4 mm long; corolla rotate-campanulate; tube 2 mm long, lobes linear-lanceolate, twisted, 4–5 mm long, densely bearded inside; corona of 5 fleshy lobes 1–3 mm long, inserted at the sinuses of the corolla, apex hairy. Fruit a pair of follicles, each one conical, up to 10 cm long, greenish, glabrous, many-seeded. Seeds with a tuft of hairs at apex.

Leptadenia comprises 4 species. *Leptadenia pyrotechnica* (Forssk.) Decne. is an erect leafless shrub of hot arid areas from Mauritania to Eritrea and Somalia, Egypt, Israel and extending to Pakistan. The other 3 species are twining leafy shrubs (in addition to *Leptadenia hastata* these are *Leptadenia arborea* (Forssk.) Schweinf. and *Leptadenia reticulata* (Retz.) Wight & Arn.). The identity of these 3 species is not clear. In fact they form a species complex, and further taxonomic research might reveal that they should be considered as a single species.

Ecology *Leptadenia hastata* is characteristic of dry savanna vegetation in semi-arid zones.

Management Propagation of *Leptadenia hastata* is by seed and sometimes it is intentionally sown near houses so that it is available when the need arises. In some parts of Ethiopia the fresh vegetable is also marketed.

Leptadenia hastata is frequently parasitized by the aphid *Aphis nerii*, which is eaten by the coccinelid *Cydonia vicinia*. *Cydonia vicinia* has been used in biological control of *Aphis craccivora*, *Aphis gossypii* and *Melanaphis sacchari*, which are said to cause transmission of rosette disease of groundnut and to attack sorghum and cotton. The cultivation of parasitized *Leptadenia hastata* in areas of these crops has been recommended as a measure to generate a population of the predatory coccinelid. More research, however, is needed to confirm activity and the practicality of planting it.

Genetic resources and breeding *Leptadenia hastata* is widespread in tropical Africa and is not in danger of genetic erosion.

Prospects *Leptadenia hastata* will remain an important emergency food in Africa, still producing under circumstances when other plants die. Its taste and nutritional value are considered appropriate and further research seems worthwhile to determine superior genotypes and possibilities for commercial cultivation. Its value as a medicinal plant and its potential role in the biological control of several diseases in groundnut, sorghum and cotton indicate the need for further investigations.

Major references Brown, N.E., 1902–1904; Bullock, A.A., 1955; Burkill, H.M., 1985; Katende, A.B., Ssegawa, P. & Birnie, A., 1999; Maundu, P.M., Ngugi, G.W. & Kabuye, C.H.S., 1999.

Other references Bullock, A.A., 1963; Busson, F., 1965; Dalziel, J.M., 1937; Kerharo, J. & Adam, J.G., 1974; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Mertz, O., Lykke, A.M. & Reenberg, A., 2001; UN-EUE, 2001c.

Authors P.C.M. Jansen

LUDWIGIA ABYSSINICA A.Rich.

Protologue Tent. fl. abyss. 1: 274 (1848).
Family Onagraceae
Chromosome number $n = 24$
Synonyms *Jussiaea abyssinica* (A.Rich.) Dandy & Brenan (1950).

Origin and geographic distribution *Ludwigia abyssinica* is widespread in Africa, occurring from Guinea east to Ethiopia, and south to Namibia, Botswana and South Africa (Natal); also in Madagascar.

Uses In DR Congo and Malawi the leaves are collected from the wild and eaten as a cooked vegetable. In Sudan and DR Congo the plant is used for the production of vegetable salt. The leaves are used in DR Congo for dressing wounds and eaten to treat abdominal pains. In East Africa a root decoction is used to treat liver diseases and intestinal worm infestations in children. The leaf sap is taken orally to prevent abortion. Cooked leaves and stems provide a black liquid that is used for dyeing straw and fibres.

Botany Stout, slightly succulent, erect or straggling herb up to 3 m tall, sometimes woody at base, much-branched, almost glabrous. Leaves alternate, simple; stipules absent; petiole up to 2 cm long; blade lanceolate or broadly elliptical, 1.5–19 cm × 0.5–4(–6) cm, cuneate at base, acute at apex, pale green above, reddish below, lateral veins 12–22 on each side of the midrib. Inflorescence a short axillary raceme, 2–17-flowered, subtended by reduced leaves. Flowers bisexual, regular, 4-merous; sepals triangular, 1.5–3 mm × 0.5–1 mm; petals nearly circular, 1–3.5 mm × 1–2.5 mm, pale yellow; stamens 4, c. 1 mm long; disk prominent, with 4 nectaries; ovary inferior, long-cylindrical, 4-celled, style short, stigma head-like. Fruit an elongate, terete capsule 1–2 cm × 1–2 mm, crowned by the persistent sepals, irregularly dehiscent, many-seeded. Seeds ellipsoid, 0.5–1 mm long, brown, each embedded in an easily detached horseshoe-shaped piece of endocarp.
Ludwigia comprises about 75 species, most of them in tropical America, and a dozen in Africa.

Ecology *Ludwigia abyssinica* grows in swampy localities along lake shores and on river banks, up to 2300 m altitude.

Genetic resources and breeding *Ludwigia abyssinica* is quite common in its large area of distribution and is not in danger of genetic erosion.

Prospects *Ludwigia abyssinica* will remain a minor vegetable. Research on its nutritional and chemical composition is desirable.

Major references Burkill, H.M., 1997; Kokwaro, J.O., 1993; Raven, P.H., 1978; Taton, A., 1967; Williamson, J., 1955.

Other references Bizzarri, M.P., 2000; Haerdi, F., 1964; Raynal, A., 1966.

Authors W.J. van der Burg

LUDWIGIA ERECTA (L.) H.Hara

Protologue Journ. Jap. Bot. 28: 292 (1953).
Family Onagraceae
Chromosome number $2n = 16$
Synonyms *Jussiaea erecta* L. (1753).
Vernacular names Yerba de jicotea (En).

Origin and geographic distribution *Ludwigia erecta* is native to tropical America and has been introduced in Africa, where it is widespread at present, from Mauritania east to Ethiopia and Somalia, and south to Angola and Mozambique; also in Comoros, Madagascar, Seychelles and Mauritius.

Uses In Somalia the leaves are cooked to make a sauce for maize and porridge. In Tanzania the leaves are occasionally eaten as a cooked vegetable. In DR Congo *Ludwigia erecta* is sometimes used as a forage. In Kenya a bath made with boiled *Ludwigia erecta* plants is given to relieve fever caused by malaria.

Botany Erect annual herb up to 3 m tall, sometimes woody at base, much-branched, glabrous. Leaves alternate, simple; stipules absent; petiole up to 1.5 cm long; blade lanceolate or elliptical, 2–13 cm × 0.5–4.5 cm, cuneate at base, acute to acuminate at apex, pale green or reddish, lateral veins 16–27 on each side of the midrib. Flowers solitary in upper leaf axils, bisexual, regular, 4-merous; sepals lanceolate, 2–6 mm × 1–1.5 mm; petals elliptical to obovate, 3–5 mm × 2–2.5 mm, golden yellow; stamens 8, c. 1 mm long; disk not prominent, with 4 nectaries; ovary inferior, long-cylindrical, 4-celled, style short, stigma globose. Fruit an elongate, 4-angled capsule 1–2 cm × 2–4 mm, crowned by the persistent sepals, irregularly dehiscent, many-seeded. Seeds oblong-ellipsoid, c. 0.5 mm long, pale brown.
Ludwigia comprises about 75 species, most of them in tropical America, and a dozen in Africa. In Madagascar young shoots of *Ludwigia adscendens* (L.) H.Hara are eaten in salads, but on mainland Africa this species is more important as forage.

Ecology *Ludwigia erecta* grows on river banks and other wet localities, as well as on moist wasteland, up to 1200 m altitude.

Genetic resources and breeding *Ludwigia erecta* is widespread and a locally common weed, and thus not liable to genetic erosion.

Prospects *Ludwigia erecta* will remain a vegetable of minor importance. Research on its nutritional and chemical composition is desirable.

Major references Burkill, H.M., 1997; Ramamoorthy, T.P. & Zardini, E.M., 1987; Thulin, M., 1993a.

Other references Bizzarri, M.P., 2000; Kokwaro, J.O., 1993; Raven, P.H., 1978; Raynal, A., 1966; Taton, A., 1967.

Authors W.J. van der Burg

LUFFA ACUTANGULA (L.) Roxb.

Protologue Hort. bengal.: 70 (1814).

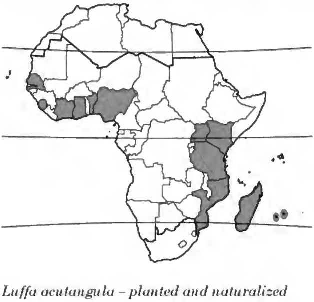
Family Cucurbitaceae

Chromosome number $2n = 26$

Synonyms *Cucumis acutangulus* L. (1753).

Vernacular names Ridged gourd, angled loofah, ribbed gourd, Chinese okra, silk squash (En). Papengaye, liane torchon (Fr). Lufa riscada (Po). Mdodoki (Sw).

Origin and geographic distribution *Luffa acutangula* is believed to have originated in India, where wild types still occur, but has now spread pantropically to all areas with a high rainfall. It is cultivated and locally naturalized in West Africa, from Sierra Leone to Nigeria. It is cultivated from the coastal areas to the semi-dry savanna, e.g. in Sierra Leone, Côte d'Ivoire, Ghana, Benin and Nigeria. In East Africa ridged gourd is grown on a small scale near the big cities as an exotic vegetable for consumers of Asian origin, and it is also locally cultivated and naturalized in Madagascar, Réunion and Mauritius. In southern and eastern Asia it is a widely cultivated vegetable.



Luffa acutangula – planted and naturalized

Uses Immature fruits of less-bitter cultivars of *Luffa acutangula* are used as a vegetable. They are cooked or fried and used in soups and sauces. Occasionally, the stem tops with young leaves and flower buds are used as a leafy vegetable. In South-East Asia, ridged gourd is a popular vegetable because of the mildly bitter flavour, the slightly spongy texture and sweet juiciness. Young fruits of sweet cultivars are also eaten raw and small fruits are sometimes pickled. The seeds yield an edible oil that is, however, sometimes bitter and toxic.

In some parts of West Africa a leaf extract of ridged gourd is applied on sores caused by guinea worms to kill the parasite. Leaf sap is also used as an eyewash to cure conjunctivitis. The fruits and seeds are used in herbal preparations for the treatment of venereal diseases, particularly gonorrhoea. In Mauritius the seeds are eaten to expel intestinal worms and the leaf juice is applied to skin affections such as eczema. The plant including the seed is insecticidal. Mature fruits when harvested dry are processed into sponges and used for scrubbing the body while bathing or for domestic purposes, such as washing of cooking utensils, and as filters for local drinks such as palm wine. Industrial use is made of these fibres for making hats. However, the sponge gourd (*Luffa cylindrica* (L.) M.Roem., synonym: *Luffa aegyptiaca* Mill.) is preferred for making sponges because its fibre is easier to extract. The trailing stem is used as temporary tying rope for firewood and crops to be carried home. The plant is occasionally used as an ornamental climber for enclosures.

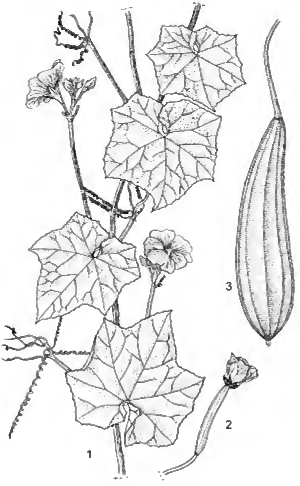
Production and international trade Ridged gourd is mainly produced as a home garden crop. Thailand exports ridged gourd to western Europe as a vegetable for the Asian communities. Japan and Brazil are the main exporters of loofah sponges mostly to the United States, but these are mainly from sponge gourd. In West Africa mature fruits of ridged gourd or sponge gourd are sold as sponges in street markets and supermarkets.

Properties The composition of ridged gourd fruits per 100 g edible portion (tough skin removed, edible portion 62%) is: water 94.2 g, energy 70 kJ (17 kcal), protein 0.8 g, fat 0.1 g,

carbohydrate 3.3 g, fibre 1.7 g, Ca 12 mg, P 32 mg, Fe 0.3 mg, carotene 26 μg, thiamin 0.07 mg, riboflavin 0.02 mg, niacin 0.4 mg, folate 37 μg, ascorbic acid 3 mg. The composition of young *Luffa* leaves per 100 g edible portion is: water 89 g, protein 5.1 g, carbohydrate 4 g, fibre 1.5 g, Ca 56 mg, Fe 11.5 mg, β-carotene 9.2 mg, ascorbic acid 95 mg (Holland, B., Unwin, I.D. & Buss, D.H., 1991). The oil content in the seeds is 26%; the fatty acid composition is: linoleic acid 34%, oleic acid 24%, palmitic acid 23% and stearic acid 10%.

Two trypsin inhibitors and a ribosome inactivating peptide (luffangulin) have been isolated from ridged gourd seeds. The glycoprotein luffaculin, also isolated from the seeds, exhibits abortifacient, antitumour, ribosome inactivating and immunomodulatory activities.

Adulterations and substitutes Young fruits of sponge gourd (*Luffa cylindrica*) are used as a substitute for ridged gourd as a vegetable, although much less popular.



Luffa acutangula – 1, shoot with male flowers; 2, female flower; 3, fruit.
Source: PROSEA

Description Monoecious, annual, climbing or trailing herb, with acutely 5-angled stem; tendrils up to 6-fid, hairy. Leaves alternate, simple; stipules absent; petiole up to 15 cm long; blade broadly ovate to kidney-shaped in outline, 10–25 cm × 10–25 cm, shallowly palmately 5–7-lobed with broadly triangular to broadly rounded lobes, cordate at base, shallowly sinuate-dentate, pale green, scabrous, palmately veined. Male inflorescence racemose with 15–35 cm long peduncle. Flowers unisexual, regular, 5-merous, 5–9 cm in diameter; receptacle tube obconic below, expanded above, c. 0.5 cm long, lobes triangular, 1–1.5 cm long; petals free, pale yellow; male flowers with 3 free stamens inserted on the receptacle tube, connectives broad; female flowers solitary, on pedicels 2–15 cm long, with inferior, densely pubescent, longitudinally ridged ovary, stigma 3-lobed. Fruit a club-shaped, dry and fibrous capsule 15–50 cm × 5–10 cm, acutely 10-ribbed, brownish, dehiscent by an apical operculum, many-seeded. Seeds broadly elliptical in outline, compressed, up to 1.5 cm long, smooth, dull black.

Other botanical information *Luffa* comprises 7 species, 4 of these native to the Old World tropics and 3 somewhat more distantly related species indigenous to South America.

In *Luffa acutangula* 3 varieties have been distinguished: var. *acutangula*, the large-fruited cultivated types; var. *amara* (Roxb.) C.B.Clarke, a wild or feral type with extremely bitter fruits and confined to India; and var. *forskalii* (Harms) Heiser & E.E.Schill., confined to Yemen, where it occurs wild or possibly as an escape. *Luffa acutangula* cultivars grown as vegetables have larger fruits and are less bitter than the wild types. In West Africa local cultivars are used as vegetables, whereas in East Africa commercial growers use improved cultivars imported from Asian countries for the Asian customers.

Growth and development Spontaneous growth of plants commences with the beginning of the rainy season. Flowering and fruiting take place throughout the rainy season, while fruits mature and seed dispersal commences as the whole plants become dry at the peak of the dry season. In cultivation, seedlings emerge 4–7 days after sowing after soaking the seeds in cold water overnight to soften the hard seedcoat. Ridged gourd tends to be day-neutral. Flowering starts 6–10 weeks after sowing. Initially male flowers are produced, later also female ones at a ratio of male to female flowers

of about 40:1. This ratio can be changed by chemical treatment. The flowers open in the evening and the stigmas have been found to remain receptive from a few hours before to 36–60 hours after anthesis. The flowers are cross-pollinated by many insects, including bees, butterflies and moths.

Ecology Ridged gourd may be common as a spontaneous plant on abandoned land, as a fallow crop and on garbage heaps. Unlike many other cucurbits it grows well in tropical lowlands. It prefers seasonal climates because dry-season planting is more successful than wet-season planting. In Africa it thrives in the dry forest or moist savanna area, around 8–10°N. Outside these latitudes, too much rain or excessive dryness often affect the development of the fruits. In humid areas growth is directed towards the production of leaf biomass, whereas under dry conditions the energy is directed towards abundant flowering. Too much heavy rainfall during flowering and fruiting leads to fruit rot. Frost is not tolerated. Ridged gourd prefers a well-drained soil with a high organic matter content and a pH of 6.5–7.5.

Propagation and planting Ridged gourd is normally grown on supports or trellises up to 3 m high. During the dry season it may also be allowed to trail on the ground, but this practice lowers the yield and quality. The seeds are sown on mounds or ridges, 2–3 seeds per hill, 50–60 cm apart in the row and 200 cm between the rows in a trellised system. Without support, 300 cm between the rows can be practised, or about one hole per m each way. Alternatively, seedlings may be raised in containers and transplanted. The 1000-seed weight is around 90 g. For direct sowing 2–3 kg seed is needed per ha, for transplanting 1–1.5 kg. In the Philippines, a planting distance of 2 m × 2 m is practised for a superior F_1 hybrid, with a seed requirement of only 500 g/ha.

Management In commercial cultivation the crop needs good care. Planting on raised beds assures good drainage in the rainy season. Irrigation is required during dry conditions at regular intervals, particularly before the flowering period. NPK fertilizer is applied to enhance growth, flowering and fruit formation. A basal dressing of NPK (e.g. 14–14–14) at the rate of 25 g/hill can be given, followed by side dressings of 20 g/hill of urea or NPK at two-week intervals. Lateral stems are pruned if they grow too abundantly. Some top and leaf pruning may promote flower and fruit development, resulting in a higher yield. For optimal production the number of fruits per stem may be limited to 20–25. For the spontaneous plants of abandoned farmland or on refuse dumps, hardly any management care is given.

Diseases and pests Ridged gourd is not very susceptible to diseases and pests. Powdery mildew (*Erysiphe cichoracearum*) and downy mildew (*Pseudoperonospora cubensis*) are reported. Fruits rot easily in contact with wet soil. In South-East Asia, the larvae of fruit flies (*Dacus* spp.) may damage young fruits; a high infection of thrips may cause stunted growth, and also caterpillars, leaf miners and aphids are reported as pests.

Harvesting Young immature fruits of 300–400 g are picked 12–15 days after fruit set. Fruits can be picked every 3 days throughout the fruiting season, by hand or with a knife. Individual plants may produce 15–20 fruits; yield declines after 8–13 weeks of harvesting. For sponge production, the fruits are left for two months on the vines till turning brown. For seed production, the seeds are shaken out of the completely dry fruits.

Yield Landraces produce 10–15 t/ha. An average yield of 27 t/ha of young fruits is reported for hybrid cultivars in the Philippines under good management.

Handling after harvest Immature fruits of ridged gourd are easily damaged. For long distance transport, the fruits have to be carefully packed. The fruits can be stored for 2–3 weeks at 12–16°C. The processing of sponges from the ripe fruits involves immersing the fruit in running water until the rind disintegrates and disappears, then the pulp and seeds are washed out, the sponges are bleached with hydrogen peroxide and dried in the sun.

Genetic resources Germplasm collections of *Luffa acutangula* are kept at genebanks in India and Taiwan, at the Institute for Plant Breeding in the Philippines, and in Nigeria at the National Centre for Genetic Resources and Biotechnology (NACGRAB) at Ibadan.

Breeding Many local cultivars are found in the Asian countries and improved cultivars are available from several seed companies. Populations are very variable. F_1 hybrid cultivars are used in several Asian countries. East-West Seed Company in Thailand developed F_1 hybrids for tropical lowland with good market quality, e.g. pale or dark green fruits, short (35 cm) to long (50 cm) fruits. Malika F_1 is a hybrid with high disease tolerance and especially suited for the rainy season.

Prospects Ridged gourd is a high yielding

and easy to cultivate vegetable. Breeding and production technology research combined with market development might give it a chance to develop into a market vegetable of importance in Africa, as in Asian countries. The use of fibre from the mature fruits and the use in agroforestry as a plant for soil rehabilitation with a heavy production of leaf biomass might be investigated.

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LYCOPERSICON ESCULENTUM Mill.

Protologue Gard. dict. ed. 8, *Lycopersicon* n. 2 (1768).

Family Solanaceae

Chromosome number $2n = 24$

Synonyms *Solanum lycopersicum* L. (1753), *Lycopersicon lycopersicum* (L.) H.Karst. (1882).

Vernacular names Tomato (En). Tomate (Fr). Tomate (Po). Nyanya (Sw).

Origin and geographic distribution The genus *Lycopersicon*, comprising 9 species, has its origin in the South American Andes, from central Ecuador through Peru to northern Chile; one species is endemic in the Galapagos Islands. Wild plants of *Lycopersicon esculentum* are more widespread and have been perhaps more recently distributed into other South American regions and into Mexico. Archaeological, ethnobotanical and linguistic evidence suggest that tomato was domesticated in Mexico, outside its centre of origin. Shortly after the Spanish conquest of Mexico in 1521, the cultivated tomato was brought to Europe, where its fruits were initially not considered

Lycopersicon esculentum – planted

edible (except in Italy) because of the erroneous assumption that they would be poisonous like many other *Solanaceae* species. Tomato was introduced from Europe to southern and eastern Asia in the 17th century and subsequently to the United States, Africa and the Middle East. Tomato has become one of the most important vegetables worldwide.

Uses Tomato fruits are consumed fresh in salads or cooked in sauces and used as a flavouring in soups and meat or fish dishes. They are made into sweetened candies, dried fruits, and even into wine. Economically equally important are the processed forms such as purée, juice, ketchup, canned whole and diced fruits.

Production and international trade World tomato production in 2001 was about 105 million t fresh fruit from an estimated 3.9 million ha. Leading tomato producing countries are China with 934,000 ha, India 500,000 ha, Commonwealth of Independent States (formerly Soviet Union) 345,000 ha, Turkey 225,000 ha, Egypt 181,000 ha, United States 164,000 ha and Italy 124,000 ha. In 2001 world exports of fresh tomato fruits were estimated at 4 million t, valued at 3000 million US$ (mainly from Spain, Netherlands and Mexico with about 600 million US$ each). World export of tomato paste is about 1.8 million t, valued at 1000 million US$ (mainly from Italy with 400 million US$). The area used for tomato production in tropical Africa is about 300,000 ha with an estimated annual production of 2.3 million t. Nigeria is the largest producer with 126,000 ha and an annual production of 879,000 t. There is some international trade of fresh tomatoes between African coun-

tries, but no data are available. South Africa exports fresh tomato fruits to neighbouring countries. In Zimbabwe and Zambia, there is a small but growing export of dried fruits to Europe.

Properties Fresh ripe tomato fruits contain per 100 g: water 93.1 g, energy 73 kJ (17 kcal), protein 0.7 g, fat 0.3 g, carbohydrate 3.1 g, Ca 7 mg, Mg 7 mg, P 24 mg, Fe 0.5 mg, Zn 0.1 mg, carotene 0.64 mg, thiamin 0.09 mg, riboflavin 0.01 mg, niacin 1.0 mg, folate 17 μg, ascorbic acid 17 mg (Holland, B., Unwin, I.D. & Buss, D.H., 1991). Most of the carbohydrate occurs as sugars. Although tomato fruits rank low in comparative nutritional value, they outrank all other vegetables in total contribution to human nutrition because so much is consumed in so many different ways. The contents of soluble solids (fructose, glucose and sucrose) and organic acids (citric, malic, galacturonic and pyrrolidone carboxylic), but even more the sugar/acid ratio, are important determinants of taste and can be assessed by standard analytical methods. However, minute quantities of numerous volatile substances also contribute to the flavour, and sensory tests remain indispensable for the judgement of the quality of tomato fruits. Some important aroma chemicals, which are associated with lycopene formation and flavour development during ripening of tomato fruits, are 6-methyl-5-hepten-2-on, β-ionone, β-damascenone and geranylaceton. Tomato fruits for processing should have a high (> 5.5%) soluble solid content. Immature fruits contain the alkaloid tomatine. Lycopene (E 160-d) is the dominant carotenoid responsible for the colour in red tomato fruits and β-carotene in yellow ones. The antioxidant properties of lycopene may contribute to protection against carcinogenic substances. The seed contains 24% of a semi-drying edible oil.

Description Annual herb, with erect to prostrate stems up to 2(–4) m long; taproot strong, to 0.5 m deep or more, with a dense system of lateral and adventitious roots; stem solid, coarsely hairy and glandular. Leaves arranged spirally, imparipinnate, in outline 15–50 cm × 10–30 cm; stipules absent; petiole 3–6 cm long; leaflets varying in size, usually 7–9 larger ones per leaf, these ovate to oblong, 5–10 cm long, irregularly toothed and sometimes pinnatifid at base, and a variable number of smaller ones, leaflets covered with glandular hairs. Inflorescence a cyme, normally 6–12-flowered, but sometimes compound and up to 100-flowered. Flowers bisexual, regular, 1.5–2

Lycopersicon esculentum – 1, flowering shoot; 2, fruit types; 3, seed.
Source: PROSEA

cm in diameter, pendent, (5–)6(–7)-merous; calyx with short tube, green, lobes pointed, persistent and enlarging on fruit; corolla stellate, yellow, lobes becoming reflexed, caducous; stamens inserted on the corolla, anthers bright yellow, connivent to form a flask-shaped cone, surrounding the style, with an elongated sterile tip; ovary superior, 2–9-celled. Fruit a berry, globular to oblate, 2–15 cm in diameter, smooth or furrowed, green and hairy when young, glabrous and shiny, usually red, sometimes pink, orange or yellow when ripe, many-seeded. Seeds flattened ovoid, 3–5 mm × 2–4 mm, pale brown and hairy, embryo coiled in endosperm. Seedling with epigeal germination.

Other botanical information Research on phylogenetic relationships, using morphological characteristics but also molecular markers, indicates that *Lycopersicon* should be included in *Solanum* and is closely related to potato and its wild relatives. However, the systematic placement of tomato in *Solanum* (as *Solanum lycopersicum* in section or subsection *Lycopersicum*) is still controversial in that it has yet to gain universal acceptance, and the treatment in *Lycopersicon* can be justified by the maintenance of nomenclatural stability in this eco-

nomically important crop.

Lycopersicon esculentum can be hybridized with the other 8 *Lycopersicon* species, but with 2 of these, the self-incompatible *Lycopersicon peruvianum* (L.) Mill. and *Lycopersicon chilense* Dunal, hybridization is only possible with the aid of embryo culture or by pollination with a mixture of auto- and allo-pollen. Most wild *Lycopersicon* species have contributed to the genome of modern tomato cultivars.

Numerous cultivars of tomato exist. They can be variously classified, e.g. according to:

- growth habit: indeterminate, semi-determinate or determinate (bushy);
- fruit size: small round (cherry tomato, < 30 g; 'Moneymaker', 80 g), medium-large round (120–150 g), beefsteak and ribbed (> 200 g);
- fruit shape: round, heart-shaped, pear-shaped, plum-shaped, elongated or flat;
- colour of ripe fruit: red, pink, orange or yellow;
- utilization: for fresh market (direct consumption) or processing (high soluble solid content and viscosity).

In tropical Africa, many farmers still use open-pollinated cultivars, both fresh market and processing types. 'Floradade', 'Heinz 1370', 'Marglobe', 'Super Marmande', 'Moneymaker', 'Rio Fuego', 'Rio Grande' and 'Roma VF' are some of the important tomato cultivars found in tropical Africa. AVRDC cultivars 'Tanya' and 'Tengeru 97' have become popular in Tanzania, and 'Xina' (from ISRA) in West Africa. It is expected that F_1 hybrids will increasingly replace open-pollinated cultivars. In West Africa F_1 'Mongal' is gaining importance. It is heavy yielding and suitable for cultivation under hot and humid conditions. Many farmers in lowland tropical Africa and the Caribbean grow local cultivars of uncertain origin. They have somewhat sour and bitter-tasting fruits, small, round or flat, many-celled, and are especially suitable for grinding with condiments for sauces. They show considerable genetic variation including disease resistance, e.g. to bacterial wilt and fungal diseases. They give a better yield than most imported cultivars under the heavy environmental stress of the rainy season.

Growth and development Dry seed (5.5% moisture content) extracted from fully mature fruits remains viable for several years at ambient (18–24°C) temperatures. Seeds germinate within 6 days after sowing at optimum soil temperatures (20–25°C). Seedlings have a thin taproot and ovate cotyledons; the first leaves have few leaflets. On the main stem 7–14 leaves are usually formed before the apex is transformed into a terminal inflorescence. Further growth is sympodial. In indeterminate cultivars sympodial growth continues indefinitely with inflorescences every 3rd leaf and fruits maturing sequentially over a long period of time. In determinate types growth is arrested after 4–6 inflorescences, when the primary axillary bud of the last leaf aborts and the next bud develops into a slower growing shoot with one leaf and a terminal inflorescence. Strong axillary bud development at the base of determinate types produces their bushy habit with several stems and a short period of prolific flowering followed by a period when fruit growth is dominant. In processing tomato fruits, synchronization of fruit growth and ripening is such that once-over machine harvesting is possible.

Under optimum conditions first flowering starts 5–7 weeks after sowing. *Lycopersicon esculentum* is autogamous, but up to 47% natural cross-pollination may take place. Bees and bumble bees are the most important pollinators; they are also increasingly used in glasshouses to stimulate anther dehiscence. Anthesis starts at around 6 a.m. and anther dehiscence takes place from 7–10 a.m., depending upon temperature, humidity and sunshine. Pollen grains remain viable for 2–5 days at temperatures ranging from 18–25°C. The stigma becomes receptive 16–18 hours before anthesis and remains so for 5–6 days at an optimum temperature of 18–25°C. High temperatures affect the viability of pollen grains and egg cells, resulting in a high degree of outcrossing in the tropics. More than 60 genes of male sterility have been reported in tomato. Many of these genes are recessive, but very few have found application in hybrid seed production so far, due to environment-dependent variation in expression of male sterility. Pollen tube growth is slow and fertilization takes place 50–55 hours after pollination. Fruits are mature 6–8 weeks later. Adequate seed set is necessary for normal fruit development, but parthenocarpic fruit set occurs in some types, or can be induced by growth regulators. The duration to peak harvest (50% of the crop) depends on cultivar and season: in the cool season 90–110 days after transplanting, during the hot season after 60–90 days. Each fruit contains numerous seeds embedded in its locules, ranging from 50–80 in cherry tomato to as many as 250 in fresh market cultivars.

Ecology Tomato requires a relatively cool, dry climate for high yield and premium qual-

ity. However, it is adapted to a wide range of climatic conditions, from temperate to hot and humid tropical. The optimum temperature range for growth and development is 20–27°C. Prolonged exposure to temperatures below 10°C can cause chilling injury, below 6°C can result in plant death. Mean temperatures below 13°C and above 27°C severely impair fruit set. Destruction of pollen and egg cells occurs when the maximum daytime temperature is 38°C or more for 5–10 days. Fruit set is generally poor at night temperatures above 20°C for a few days before and after anthesis. Hot dry winds can also cause flower abortion. Light intensities below 11,000 lux retard plant growth and delay flowering. Tomato is not sensitive to daylength and sets fruit in photoperiods ranging from 7–19 hours.

Tomato can be grown in many soil types, from sandy loam to clay-loam soils that are rich in organic matter. It is sensitive to waterlogging and flooding and prefers well-drained soils. The optimum soil pH range is 6.0—7.0; higher or lower pHs can cause mineral deficiencies or toxicities.

Propagation and planting Tomato seeds are considered non-dormant. Tomato can be direct-seeded or transplanted in the field. Relatively little seed-drilling or direct sowing into the field is practised in the humid tropics because of adverse growing conditions. In contrast, raising young transplants in a nursery enables growers to obtain uniform seedlings and to check early diseases and pests. Other advantages of transplanting are the smaller quantity of seed needed and reduced competition from weeds in the field. The 1000-seed weight is 2.5–3.5 g. To raise transplants, 150–200 g seeds are sown per 250 m^2 of seedbed, which provides enough plants for 1 ha. When direct-seeded, the sowing rate is 500–1000 g seed per ha. Fertilizer at a rate of 10 g N, 10 g P, 15 g K and 2 kg farmyard manure per 1 m^2 of seedbed area should be worked into the seedbed. The young seedlings require ample water to sustain good, healthy growth. Seedling losses caused by damping-off diseases are often controlled effectively by solarization of the seedbed, or by drenching the soil with fungicides such as Previcur N (propamocarb-hydrochloride), prior to sowing. A week before transplanting, watering should be reduced to harden the seedlings. Seedlings are ready for transplanting when 3–4 weeks old (15–25 cm tall with 3–5 true leaves). They should be thoroughly watered 12–14 hours before they are lifted out of the seed-bed to avoid excessive damage to the roots. Transplanting should be done in the afternoon or on a still, cloudy day to reduce the transplanting shock, and should be followed by watering. Spacing between plants and distance between rows depends on the cultivar's growth habit and whether the plants are to be supported by stakes or left to grow on the ground. Common spacings are 30–60 cm apart in single or double rows on 1.0–1.4 m wide beds.

Management Nutrition plays a major role in increasing productivity. Fertilizer for tomato should be fairly rich in phosphorus. Excess nitrogen is associated with excessive vegetative growth, fruit puffiness and blossom-end rot. The amount of fertilizer and the timing of its applications vary with soil type and cultivar. In tropical Africa, fertilizer recommendations include 80–180 kg N, 80–200 kg P, 80–200 kg K and 25 t of farmyard manure per ha. The entire doses of farmyard manure and phosphorus are applied before transplanting. The farmyard manure is applied before final ploughing, whereas phosphorus is applied on both sides of the rows and mixed with the top 8–10 cm of soil. Nitrogen and potassium are applied in three equally split doses. The first dose is given before transplanting as basal dressing, the second one 3 weeks after transplanting, and the last one 2 weeks later.

Indeterminate cultivars are often grown on stakes. Pruning their lateral shoots is often practised, to produce fruits of good and uniform size. Sufficient leaves should be left on the plant to prevent sun scalding (direct insolation) and cracking (after excessive rain or irrigation) of the fruits. Depending on local practice only 1–2 stems may be allowed to grow. The number of fruits per cluster as well as the number of clusters may also be regulated. Little pruning or regulation of fruit number and clusters is normally practised on determinate cultivars.

Competition from weeds, especially in the hot and humid tropics, can be very severe. To control weeds, a pre-emergence herbicide may be used before transplanting, supplemented by manual weeding and mulching the beds with straw. Crop rotation with non-solanaceous crops is recommended to reduce soil-borne diseases and pests.

Tomato needs adequate irrigation during the early plant growth, fruit set and fruit enlargement stages. About 20 mm of water per week is needed under cool conditions; about 70 mm during hot and dry periods. Constancy of water

supply plays a major role in attaining uniform maturity and reducing the incidence of blossom-end rot, a physiological disorder associated with irregular water suply and the resulting calcium deficiency in the fruit during its enlargement.

Diseases and pests Some 45 diseases and more than 20 pests may attack the tomato plant, but only those having a depressing effect on yield and fruit quality in tropical Africa are described here. Bacterial wilt (*Ralstonia solanacearum*) is the most important soilborne disease in tropical regions, particularly in the humid lowlands. Some of the recommended methods to prevent or reduce bacterial wilt infection are the use of resistant/tolerant cultivars, long-term crop rotation, e.g. with cereals, planting tomato after paddy rice or flooding the field for 3–4 months before planting, but avoiding land previously cropped with banana. There is no effective chemical control. Bacterial wilt resistance also provides some protection against bacterial canker (*Clavibacter michiganense*). Bacterial spot (*Xanthomonas campestris* pv. *vesicatoria*) can be serious during the rainy season and is most noticeable on fruits, but also causes damage to the foliage and stems. It is transmitted by seed. Spraying with copper fungicides can control this disease fairly well except under heavy infection.

Soilborne fungal diseases such as Fusarium wilt (*Fusarium oxysporum* f.sp. *lycopersici*) and Verticillium wilt (*Verticillium dahliae*) sporadically occur in tropical highlands. Host resistance is present in several tomato cultivars. The stem base of tomato plants can be affected by southern blight (*Sclerotium rolfsii*), especially in the presence of poorly decomposed organic matter, and by Phytophthora root rot (*Phytophthora parasitica* and *Phytophthora capsici*) under excessive irrigation or rainfall. Potentially very destructive fungal diseases affecting leaves, stems and fruits are early blight (*Alternaria solani*) in hot and humid lowlands and late blight (*Phytophthora infestans*) in the cooler tropical highlands during the rainy season. Fungicide sprays remain the only means to control early blight, but for late blight commercial cultivars with host resistance are gradually becoming available. Other fungal diseases include grey leaf spot (*Stemphylium* spp.), leaf mould (*Fulvia fulvum*), black leaf mould (*Pseudocercospora fuliginea*), internal powdery mildew (*Leveillula taurica*), Septoria leaf spot (*Septoria lycopersici*) and target spot (*Corynespora cassiicola*). Cultivars with resistance to grey leaf spot and leaf mould are adequately protected against these two diseases under tropical conditions.

Important virus diseases in tropical Africa are tomato yellow leaf curl virus (TYLCV) and tomato spotted wilt virus (TSWV). Depending on the virus, transmission is by whitefly (*Bemiciatabaci* for TYLCV) and thrips (*Frankliniella* spp. for TSWV). Some varieties tolerant to these two viruses have recently become available. Raising tomato seedlings under an insect-proof net, early control of the insect vectors and general field sanitation can serve well to control TYLCV and TSWV.

Where two different major diseases occur, host resistance in a cultivar to both pathogens is of great advantage. Examples are F_1 hybrid cultivar 'Opal' for bacterial wilt and late blight (at intermediate altitudes) and F_1 hybrids 'Mongal' and 'Somtam' for bacterial wilt and TYLCV.

Among the insect pests, the polyphagous tomato fruitworm or army worm (*Helicoverpa armigera*) is one of the most destructive, causing yield losses as high as 70% due to fruit boring. A spray programme with Biobit 2X (*Bacillus thuringiensis*) or locally approved insecticides provides good control of eggs and caterpillars before fruit entry. Tomato should not be planted near alternative hosts such as maize or cotton. Whitefly (*Bemisia tabaci*) is a serious pest, not only because of its foraging on tomato plants, but also because it is a vector of TYLCV. The recent aggravation of TYLCV in tropical Africa is probably linked to the proliferation of whitefly due to the excessive use of synthetic pyrethroids. The thrips *Frankliniella occidentalis* has become a problem as the main vector of TSWV. Aphid proliferation is somewhat reduced by glandular hairs. On the other hand, the mite *Aculops lycopersici* (synonym: *Vasates lycopersici*) feeds on such hairs, inducing bronze-like discoloration of the stem and leaf necrosis during dry and hot periods of more than two weeks. It can be controlled by sulphur dusting or spraying or with specific acaricides.

Root-knot nematodes (*Meloidogyne incognita* and other species) invade tomato roots and cause galling. Yield losses caused by direct infection and indirect losses due to predisposition or breakdown of resistance to other root diseases, such as bacterial wilt, are significant. The use of resistant cultivars, e.g. F_1 'Mongal', 'Tengeru 97' or 'Xina' (resistant also to *Xanthomonas*), is still the most cost-effective measure, although breakdown of resistance can oc-

cur at high soil temperatures. So far, no host resistance to *Meloidogyne hapla* has been found. Cultural measures to avoid nematode infestations are crop rotation with non-hosts (grasses, amaranths) and increasing the organic matter content of the soil. Occasional fruit damage by birds feeding on the seeds may require bird-scaring or growing the tomato plants under netting.

Harvesting Fresh-market tomato fruits are often harvested at different stages of ripeness, from mature green to pale pink, depending upon distance and time needed to market the fruit. Generally, fruits harvested at pre-ripe stages tend to have lower quality (i.e. lower soluble solids, ascorbic acid and reducing sugars) than fruits ripened on the plant. The nature of the growth and ripening pattern of fresh-market tomato cultivars requires frequent pickings.

In contrast to the fresh-market or table tomato fruits, processing fruits are picked when fully ripe. In developed countries harvesting is often by machine. Tomato fruits used for pureed products such as soup, juice and sauce, are left on the plant until over 85% of them are ripe. Those for whole fruits are picked while still firm, but often only 65% of the crop may be ready to pick at any one time. So-called 'jointless' fruit stalks allow mechanical harvesting of processing fruits devoid of stalk and calyx. On the other hand, stalks and calyx usually remain attached to fresh-market tomato fruits as a result of jointed stalks.

Yield The world's average tomato yield in 2001 was 27 t/ha, but in tropical Africa only 8 t/ha of fruits are obtained on average from an open-field tomato crop. Some average yields per country are: Nigeria 7 t/ha, Kenya 12 t/ha, Egypt 35 t/ha, France 120 t/ha. Extremely high tomato yields of 450–500 t/ha are obtained in heated and lighted glasshouses in the Netherlands with a harvesting period of 9 months from a single crop.

Seed yields are 100–150 kg/ha for F_1 hybrids and up to 300 kg/ha for open-pollinated cultivars.

Handling after harvest After picking, tomato fruits may be moved to a shady place to prepare them for the market. Properly sorted and graded fruits generally command a better market price than ungraded ones. The marketable fruits are packaged in containers, often 10–25-kg wooden or plastic boxes. Processing tomato fruits are popular in market gardens in the tropics because their firmer fruit better withstands long-distance transport over bad roads. Storage life of tomato fruits depends on the maturity stage at which they were picked and on the desired quality. Quality is highest when completely ripe, whether ripened artificially or on the plant. Ideally mature-green tomatoes should be stored for 7–10 days at 13–18°C with 85–90% relative humidity to ripen properly. Tomato fruits of modern 'long-shelf life' F_1 hybrid cultivars, which combine fruit firmness with delayed ripening, can be harvested at the red-fruit stage and still be stored for more than two weeks before consumption. Colour is the single most important visual parameter of tomato quality as lycopene formation is also correlated with flavour. Lycopene development at temperatures above 30°C is generally poor. This is the main reason why many non-adapted tomato cultivars grown in the hot tropics tend to have a pale red or yellowish colour and are poorly flavoured.

Genetic resources Many institutional collections of cultivated and wild *Lycopersicon* exist. Some of these collections have been well described, evaluated and documented for use by tomato scientists, the most important one being the C.M. Rick Tomato Genetic Resources Center (TGRC) at the University of California, Davis, United States. The TGRC maintains at present about 1060 accessions of the 9 *Lycopersicon* and 4 related *Solanum* species, 960 accessions of monogenic (spontaneous and induced) mutants affecting all aspects of plant development, introgressed disease resistance genes and protein marker stocks, and 1190 miscellaneous accessions including linkage tester stocks, trisomics, translocations, Latin American cultivars and various progenies from interspecific pre-breeding. A large collection is also maintained at the Asian Vegetable Research and Development Center (AVRDC) in Taiwan and the N.I. Vavilov Institute of Plant Industry (VIR) in Russia. Since modern improved cultivars are rapidly replacing the old landraces, the latter should be collected for future breeding purposes.

Breeding In tomato breeding, methods common to self-pollinated crops have been complemented with those specific to outbreeders. Selected inbred lines developed from intra- and interspecific crosses and backcrosses followed by line, pedigree and recurrent selection can be either released as cultivars or used as parent lines for the production of F_1 hybrid cultivars. Although more expensive to produce

(seed multiplication mostly by hand-pollination). F_1 hybrids are often higher yielding as a result of transgressive hybrid vigour in crosses with genetically divergent inbred lines. However, the main advantage is the potential of combining several disease resistances and other interesting plant and fruit characters in one cultivar.

Many characters, including resistance to several diseases and pests, are controlled by monogenes. However, fruit quality, resistance to diseases like bacterial wilt and TYLCV, heat tolerance and other agronomic characters are inherited polygenically. Selection requires extensive field testing and progress is often much slower. Breeding work at the University of Florida has produced cultivars, such as 'Florade' (disease resistances, firm fruits and adaptation to the hot and humid summers of Florida), which have been progenitors of several cultivars recommended for tropical climates. Other important contributions have come from Hawaii (resistance to root-knot nematodes, genetic studies on bacterial wilt and TSWV resistance), Israel (TYLCV resistance, long shelf life), French West Indies (bacterial wilt resistance and tolerance to high night temperatures), Cuba (heat resistance associated with TYLCV tolerance), France (INRA-Avignon: high levels of TYLCV resistance) and South-East Asia (AVRDC in Taiwan and Thailand: bacterial wilt and other disease resistances, heat tolerance).

Tomato is one of the best-studied crops, reflecting its great economic importance. Many important genetic traits have been discovered, evaluated and genetically localized in their respective chromosomes. Tomato has a prolifically marked genome, very useful in genetic and breeding research and has become an important subject for biotechnological studies. Much progress has already been made with molecular marker-assisted selection and genetic transformation.

Prospects Tomato scientists have accomplished a great deal in the past, including improvements in yield, disease resistance, adaptability to machine harvesting, processing and nutritional quality, and tolerance of environmental stress. However, the vast reservoir of genetic variability in *Lycopersicon* remains largely unexploited. Conventional breeding methods are still expected to be the mainstay of future improvement programmes. At the same time, molecular breeding is rapidly gaining momentum also in tomato. Its integration into existing programmes will allow plant breeders to access, transfer and combine genes at a rate, precision and genomic range never achieved by conventional methods. Indeed, the prospects for further improving the tomato crop are bright also for tropical conditions.

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Sources of illustration Opeña, R.T. & van der Vossen, H.A.M., 1993.

Authors H.A.M. van der Vossen, R. Nono-Womdim & C.-M. Messiaen

MARSILEA MINUTA L.

Protologue Mant. pl.: 308 (1771).

Family Marsileaceae

Chromosome number $2n = 40, 60$

Synonyms *Marsilea senegalensis* A.Braun ex Baker (1887).

Vernacular names Water clover (En). Marsilée, marsiléa, marsilia, fougère d'eau (Fr).

Origin and geographic distribution *Marsilea minuta* is found throughout Africa, Madagascar and the Comoros. It also occurs

widely in tropical Asia and as a weed in the southern United States.

Uses The bright green leaves of *Marsilea minuta* are tender and eaten as a potherb in Senegal, Gambia and India. In Nigeria the extract of whole *Marsilea* plants is used as aphrodisiac and for increased fertility. In India the leaf juice of *Marsilea minuta* is used to stop nose bleeding, indigestion is treated by eating the pounded leaves cooked with rice, and swelling of the gums is reduced by applying leaves that have been boiled rolled in a leaf of *Shorea robusta* P.Gaertn. Water clover is planted as an ornamental potplant and is used more commonly as a garden plant for pond decoration.

Properties No studies of the nutritional value or plant constituents are known. When fed to gerbils, a leaf extract of *Marsilea minuta* reduced cholesterol and triglyceride levels in blood and liver substantially. Moreover, the treatment prevented the accumulation of these compounds in liver and aorta and dissolved atheromatous plaques of thoracic and abdominal aortas.

Botany Small creeping fern with erect 4-foliolate leaves, arising solitary from the nodes on a long creeping rhizome, rooting at the nodes. Leaves composed of 4 obdeltoid leaflets, 0.4–2.5 cm long and wide, all inserted at the top of the slender 2–8(–25) cm long petiole. Sporocarps crowded or in groups of 2–3, arising at the base of the petiole, on stalks of (2–)3–7 mm long, laterally flattened, very variable in size, 3–4(–6) mm × 2.5–3(–4.5) mm, circular to elliptical, densely appressed-pilose when young, quite glabrous and dark brown to almost black when mature, with two distinct teeth and 8–12 sori.

Marsilea minuta is the widest distributed species of the genus and also the most variable. Var. *incurva* (A.Braun) Launert is found from Senegal to Ghana and differs from var. *minuta* in the angle between stalk and sporocarp, which exceeds 90°. The numerous misidentifications in *Marsilea* hinder the interpretation of scientific work.

Marsilea quadrifolia L., a circumboreal species, is often mentioned as occurring in Africa, but this is certainly not correct for sub-Saharan Africa, and all information published for *Marsilea quadrifolia* in this area must be attributed to other species.

Ecology *Marsilea minuta* grows in swamps, stagnant water, edges of rivers and seasonally flooded land. It also occurs in wet rice fields, where it sometimes becomes a nuisance because it forms large and dense colonies.

Management In Nigeria *Marsilea* is recorded as being grown near the house for ready use as an aphrodisiac and as an ornamental.

Genetic resources and breeding *Marsilea minuta* is widespread and not threatened by genetic erosion. No germplasm collections of *Marsilea* are known.

Prospects *Marsilea* is traded on a limited scale as an ornamental because of its peculiar leaves. However, because of the fact that they have four leaflets, which by tradition brings good luck if found in clovers, the plant may remain a specialty for a long time to come.

Major references Afriastini, J.J., 2003; Burkill, H.M., 2000; Gupta, R.S., Kumar, P., Sharma, A., Bharadwaj, T.N. & Dixit, V.P., 2000; Nwosu, M.O., 2002; Tattersall, S.L., 1978.

Other references Alston, A.H.G., 1959; Launert, E., 1968; Launert, E., 1984; Swaminathan Research Foundation, M.S., undated.

Authors W.J. van der Burg

MAYTENUS HETEROPHYLLA (Eckl. & Zeyh.) N.Robson

Protologue Bol. Soc. Brot., sér. 2, 39: 17 (1965).

Family Celastraceae (Hippocrateaceae)

Synonyms *Gymnosporia buxifolia* (L.) Szyszyl. (1888).

Vernacular names Common spike-thorn (En).

Origin and geographic distribution *Maytenus heterophylla* is distributed from eastern DR Congo, Sudan and Eritrea extending south to southern Africa, but it is not recorded from Namibia; it also occurs in Madagascar.

Uses The roots of *Maytenus heterophylla* are boiled and eaten as a vegetable by the Maasai. The wood is very hard and heavy and resembles boxwood (*Buxus*). It is suitable for making small objects such as spoons and stools, for carving and for throwing sticks ('knobkerries'). Medicinal uses are reported throughout its range. The leaves are used against painful menstruation, a bark infusion to treat diarrhoea and as an emetic, and roots as an anthelmintic, against hernia and as a cure for syphilis. Unspecified plant parts are used as a remedy for snakebite, epilepsy, abscesses and convulsions in children. A leaf and bark infusion is used against diarrhoea in cattle.

Properties Antimicrobially active ethanol extracts of leaves and bark of *Maytenus heterophylla* yielded a dihydroagarofuran alkaloid, 1β-acetoxy-9α-benzoyloxy-2β,6α-dinicotinoyloxy-β-dihydroagarofuran. Various β-dihydroagarofuran sesquiterpene polyesters isolated from members of *Celastraceae* have been found to have insecticidal and/or insect antifeedant activities. Other compounds that have been isolated are β-amyrin, maytenfolic acid, 3α-hydroxy-2-oxofriedelane-20α-carboxylic acid, lup-20(29)-ene-1β,3β-diol, (–)-4'-methylepigallocatechin, and (–)-epicatechin. Maytenfolic acid has moderate antimicrobial activity; it showed growth inhibition of *Candida albicans*, *Cryptococcus neoformans*, *Staphylococcus aureus* and *Pseudomonas aeruginosa*. Dulcitol has been isolated from unspecified plant parts. Maytansinoids have been isolated from other *Maytenus* species, which have shown significant antitumour and antileukaemic activities.

Botany Dioecious shrub or small tree, up to 6 m tall, with spines up to 3.5 cm long. Leaves alternate or fasciculate, simple; stipules free, somewhat persistent; petiole 1–4 mm long; blade elliptical, oblanceolate or spatulate, 1–6 cm × 0.5–2.5 cm, base cuneate, apex usually obtuse, margin serrulate to almost entire, glabrous on both sides. Inflorescence an axillary 3–12-flowered cyme, 0.5–2(–3.5) cm long. Flowers bisexual, regular, 5-merous, up to 6 mm in diameter; sepals up to 2 mm long; petals up to 3 mm long, greenish white to yellow. Fruit an obovoid to globose capsule, brown when dry, 2–4-seeded. Seeds c. 3 mm × 2 mm, glossy, reddish brown, with yellow aril covering from one- to two-thirds of the length of the seed.

The generic limits of *Maytenus* are presently under review. It is likely that *Maytenus heterophylla* will be transfered to the genus *Gymnosporia*.

Ecology *Maytenus heterophylla* occurs in forest, forest margins and woodland, often on sandy and riverine localities at altitudes from sea-level to 3000 m.

Genetic resources and breeding *Maytenus heterophylla* is widely distributed and not threatened. The variation in morphology is especially large in the southern part of its range. The variation in the content of maytansinoids in *Maytenus* is large and not fully understood; the variation is not documented for *Maytenus heterophylla*.

Prospects Interest in *Maytenus heterophylla* is likely to increase because of its medicinal properties. A definite taxonomic assessment of *Maytenus* and close relatives is indispensable for research into pharmacological properties of the genus and related species.

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Other references Orabi, K.Y., Al-Qasoumi, S.I., El-Olemy, M.M., Mossa, J.S. & Muhammad, I., 2001; Robson, N.K.B., 1989; Robson, N.K.B., Hallé, N., Mathew, B. & Blakelock, R., 1994.

Authors C.H. Bosch

MEDINILLA MIRABILIS (Gilg) Jacq.-Fél.

Protologue Adansonia, ser. 2, 17(1): 78 (1977).

Family Melastomataceae

Synonyms *Myrianthemum mirabile* Gilg (1897).

Origin and geographic distribution *Medinilla mirabilis* is found in Nigeria, Cameroon and Gabon.

Uses In Gabon the young leaves of *Medinilla mirabilis* are collected from the wild and eaten as a cooked vegetable, often with fish or meat, giving it an acidulous taste. Heated leaves are applied to cicatrize wounds. The leaves mixed with melegueta pepper (*Aframomum melegueta* K.Schum.) serve as a cough medicine.

Botany Climbing shrub or liana, with rounded, glabrous, often purplish stem up to 10 m long. Leaves usually arranged in whorls of 4, simple, slightly leathery, young leaves wine red; petiole up to 2 cm long; blade obovate-elliptical, 15–30 cm × 5–15 cm, base rounded, apex rounded or acuminate, margin entire or sparsely and obscurely toothed, 3–5-veined, with transverse veinlets. Inflorescence a cyme arranged in dense clusters at the nodes of woody stem near ground level. Flowers bisexual, regular, 4-merous; pedicel slender, 3–5 cm long; hypanthium globular-ellipsoid, c. 4.5 mm long; calyx campanulate, with short lobes or teeth; petals free, ovate to orbicular, c. 7 mm × 3 mm, slightly fleshy, pink to purplish; stamens 8, arranged in 2 whorls of 4, unequal, anthers with 2–3-lobed appendix at base, opening by an apical pore; ovary inferior, completely connate with hypanthium, many-celled, style slightly curved, c. 7 mm long, stigma flattened. Fruit an urceolate false berry up to 1.5 cm long, dark purple, many-seeded. Seeds wedge-shaped, c. 1 mm long.

Medinilla comprises about 400 species, the majority of which are found in tropical Asia. In mainland Africa only 3 species occur, but in Madagascar about 70.

Ecology *Medinilla mirabilis* is restricted to rainforest. It is fairly common in Cameroon and Gabon, less common in Nigeria, from sea-level up to 700 m altitude.

Genetic resources and breeding *Medinilla mirabilis* is not widespread and liable to genetic erosion with progressive deforestation.

Prospects *Medinilla mirabilis* will remain a minor wild vegetable. Research is needed on its nutritional and medicinal properties for a reliable evaluation. *Medinilla mirabilis* is a peculiar, beautiful liana with potential for use as an ornamental.

Major references Burkill, H.M., 1997; Jacques-Félix, H., 1983; Raponda-Walker, A. & Sillans, R., 1961.

Other references Keay, R.W.J., 1954c.

Authors P.C.M. Jansen

MELOCHIA CORCHORIFOLIA L.

Protologue Sp. pl. 2: 675 (1753).

Family Sterculiaceae (APG: Malvaceae)

Chromosome number $2n = 36, 46$

Vernacular names Chocolate weed, redweed, wire bush (En). Herbe à balai (Fr). Mpopo (Po). Pombo (Sw).

Origin and geographic distribution *Melochia corchorifolia* is widespread in tropical Africa, Asia and Australia. It has been introduced in America and is widely naturalized there.

Uses The leaves of *Melochia corchorifolia* are eaten as a potherb in West Africa and southern Africa. The cooked leaves provide a popular, slimy side-dish in Malawi. Similar use of the leaves is reported from Indo-China and India. *Melochia corchorifolia* is eagerly browsed, either green or dry, by cattle in Sudan but less so in Senegal. Fibres extracted from the bark are fine and strong and are used like those of *Triumfetta*, *Urena* and *Hibiscus*. The stems are used for tying bundles and are used in the construction of conical roofs for local houses. Leaves are used for unspecified stomach disorders in coastal East Africa. In Benin the seed is used to treat stomachache. In Malaysia and India the leaves and roots are used to treat a wide range of medical problems: urinary disorders, abdominal swelling, dysentery, snakebites and sores. An aqueous solution of leaves has insecticidal properties. Pulses stored in gunny bags treated with the solution have shown a reduction in the number of eggs laid and in damage done by the storage pest *Callosobruchus*.

Properties Phytochemical analysis of leaves of *Melochia corchorifolia* has revealed the presence of triterpenes (friedelin, friedelinol and β-amyrin), flavonol glycosides (hibifolin, triflin and melocorin), aliphatic compounds, flavonoids (vitexin and robunin), β-D-sitosterol and its stearate, β-D-glucoside and alkaloids. A pyridine alkaloid, 6-methoxy-3-propenyl-2-pyridine carboxylic acid, may be important as related pyridine derivatives are physiologically active.

Melochia tomentosa L. and *Melochia pyramidata* L., both originating from tropical America, have been implicated in poisoning and causing paralysis and tumours.

Botany Annual or perennial herb, erect to spreading, up to 1.3(–2.0) m tall; stem with a line of stellate hairs. Leaves arranged spirally, simple; stipules subulate-lanceolate, c. 1 cm long; petiole 0.5–2(–3) cm long; blade narrowly to broadly ovate, up to 7.5 cm × 5.5 cm, base

Melochia corchorifolia – 1, plant habit; 2, flowers; 3, fruit; 4, seed.
Source: PROSEA

cuneate to truncate, apex acute to rounded, margin acutely serrate, (3–)5-veined from the base. Inflorescence a condensed axillary or terminal cyme. Flowers bisexual, regular, 5-merous; calyx campanulate, c. 3 mm long, short-teethed; petals obovate, c. 8 mm long, white with yellow base inside; stamens united almost to the top of the filaments; ovary superior, 5-celled, styles 5, united at base. Fruit a globose, 5-valved capsule c. 5 mm in diameter, few-seeded. Seeds 3-sided, c. 3 mm × 2.5 mm, striate.

Melochia comprises about 50 species, with 3 species occurring in mainland tropical Africa. *Melochia melissifolia* Benth. is found in both tropical Africa and tropical America. It occurs in swampy grassland and on waste ground. It differs from *Melochia corchorifolia* in the all-round pubescence of the stems. Both species are highly variable and have similar uses.

Ecology *Melochia corchorifolia* is mostly found in sunny or slightly shaded, humid localities such as river banks, lake shores and alluvial plains. It is a common and important weed, notably in rice (both upland and lowland), soybean, cotton and cassava.

Management In the literature mention is made of cultivation of *Melochia corchorifolia*, but no details seem to have been published. Propagation is done by seed; germination can be improved considerably by scarification. Scarified seed germinates best at temperatures of 35–40°C. *Melochia corchorifolia* is reported to be a host of fungal diseases (*Rhizoctonia solani*).

Genetic resources and breeding Genetic erosion is not likely as the geographical distribution of *Melochia corchorifolia* is extensive.

Prospects *Melochia corchorifolia* will remain locally of some importance as a collected vegetable. Its weedy nature warrants caution for promoting wider use and cultivation. Quite some research has been done on the phytochemistry but little is known about the pharmacological properties of its compounds.

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Sources of illustration Ysrael, M.C., 1999.

Authors C.H. Bosch

MICROCOCCA MERCURIALIS (L.) Benth.

Protologue Hook., Niger Fl.: 503 (1849).

Family Euphorbiaceae

Chromosome number $2n = 20$, 40, 60

Synonyms *Tragia mercurialis* L. (1753), *Mercurialis alternifolia* Lam. (1797), *Claoxylon mercurialis* (L.) Thwaites (1861).

Origin and geographic distribution *Micrococca mercurialis* occurs throughout tropical Africa, Yemen, India, Sri Lanka, western Malaysia and northern Australia.

Uses In Benin and Gabon leaves of *Micrococca mercurialis* are eaten as a vegetable. In Uganda leaves are widely used as a vegetable and the method of preparation and popularity differs by region. They are sold in local markets, and dried and pounded to powder for storage and later use. In Congo the plant is used to treat fever in children, and plant sap is instilled into nose, eyes or ears to treat headache, filariasis of the eye and otitis, respectively.

Properties The leaves of *Micrococca mercurialis* have an acid taste.

Botany Annual herb up to 60 cm tall. Leaves alternate; stipules small, early caducous; petiole up to 3.5 cm long; blade ovate to lanceolate, 2–7.5 cm × 1–4 cm, rounded at base, apex acuminate, margin crenate, glabrescent to subglabrous, dull grey-green. Inflorescence a raceme 3–12 cm long, with flowers arranged interruptedly in clusters of 1 female flower and several male flowers. Flowers unisexual, pedicel 2 mm long, petals absent; male flowers with 3 calyx lobes less than 1 mm long, yellow-green, stamens 3–20 (in African specimens often 9), disc glands stipitate, spatulate, purple; female flowers with 3–5 calyx-lobes, lanceolate, 2 mm long, green with hyaline margin, ovary superior, 3-lobed, styles 3, 1 mm long, disc glands linear-filiform, 1 mm long. Fruit a subglobose, 3-lobed capsule 2.5 mm × 4 mm, strigose, purplish. Seeds angular-subglobose, 2 mm × 1.5 mm, pink-brown to blackish.

Micrococca comprises about 12 species, and is distributed in the tropics of the Old World. *Micrococca mercurialis* comprises a polyploidal complex selected by climate, which determines the duration of the growth cycle: $2n = 20$ (diploid, dry sudan zone, short growth cycle), $2n = 40$ (tetraploid, intermediate guinean zone), $2n = 60$ (hexaploid, humid dense forest zone, long or continuous growth cycle).

Ecology *Micrococca mercurialis* grows in

open places in woodland and bushland, along rivers and shores, commonly in ruderal habitats, sometimes as a weed, from sea-level up to 1700 m altitude.

Management In many places *Micrococca mercurialis* is not cultivated but grows as a weed in gardens and fields. However, in Uganda it is cultivated both for sale and domestic use and where it occurs naturally it usually is protected. The dried powdered leaves can be stored for over a year.

Genetic resources and breeding *Micrococca mercurialis* is widespread and not in danger of genetic erosion.

Prospects Research is needed on the nutritive and medicinal values of *Micrococca mercurialis*, and also cultivation methods merit more research.

Major references Bouquet, A., 1969; Burkill, H.M., 1994; Katende, A.B., Ssegawa, P. & Birnie, A., 1999; Radcliffe-Smith, A., 1987; Raponda-Walker, A. & Sillans, R., 1961.

Other references Berhaut, J., 1967; Champault, A., 1970; Govaerts, R., Frodin, D.G. & Radcliffe-Smith, A., 2000; Radcliffe-Smith, A., 1996; Sagun, V.G. & van Welzen, P.C., 2002; van der Zon, A.P.M. & Grubben, G.J.H., 1976.

Authors P.C.M. Jansen

MOMORDICA BALSAMINA L.

Protologue Sp. pl. 2: 1009 (1753).

Family Cucurbitaceae

Chromosome number $2n = 22$

Vernacular names Balsam apple, african cucumber, southern balsam pear (En). Margose, courgette africaine, concombre balsamite (Fr). Balsamina de purga, balsamina pequena (Po).

Origin and geographic distribution *Momordica balsamina* occurs throughout Africa south of the Sahara, but not in the Indian Ocean islands; it is also found in Yemen, India and Australia. It occurs wild in tropical America as well, probably as a result of introduction.

Uses The leaves and young fruits of *Momordica balsamina* are cooked and eaten as a vegetable in Cameroon, Sudan and southern Africa. The bitter young fruits have been reported widely as edible, whereas the ripe fruits cause vomiting and diarrhoea, and can be poisonous. The bright red fruit pulp is eaten in Namibia.

The leaves and stems serve as camel fodder. In Senegal donkeys, cattle, sheep and goats feed on it but horses avoid it. In Queensland, Australia, leaves and flowers were fed to sheep without causing problems. The leaves are used to clean metal objects and to wash hands and body. They form a slightly soapy solution in water. Medicinal use of *Momordica balsamina* is widespread and diverse. Common, widespread uses are as an anthelminthic (fruits, seeds and leaves), against fever and excessive uterine bleeding (leaves), and to treat syphilis, rheumatism, hepatitis and skin disorders. Other uses are as an abortifacient, aphrodisiac and lactogenic, and in treating diabetes. The whole plant, together with *Strophanthus*, is used in the preparation of an arrow poison in parts of Nigeria. Ripe fruits may have caused the death of dogs and pigs.

Properties The composition of the leaves per 100 g is: water 89.4 g, protein 3.0 g, fat 0.1 g, carbohydrate 3.6 g, fibre 0.9 g, Ca 340 mg, Mg 87.1 mg, P 27.7 mg, Fe 12.7 mg, Zn 0.9 mg, thiamin 0.01 mg, riboflavin 0.09 mg, niacin 0.7 mg, ascorbic acid 0.4 mg.

The composition of the fruits per 100 g is: water 89.4 g, protein 2.0 g, fat 0.1 g, carbohydrate 5.1 g, fibre 1.8 g, Ca 35.9 mg, Mg 41.2 mg, P 35.8 mg, Fe 2.6 mg, Zn 1.0 mg, thiamin 0.04 mg, riboflavin 0.06 mg, ascorbic acid 0.5 mg (Arnold, T.H., Wells, M.J. & Wehmeyer, A.S., 1985).

The bitter taste of all parts of *Momordica balsamina* may be caused by cucurbitacins, as in many other *Cucurbitaceae*, but may also be caused by saponins. The ribosome inactivating protein momordin II has been isolated, as well as the caffeic acid ester rosmarinic acid, which is of pharmaceutical interest because of its anti-inflammatory, antiviral, antibacterial and antioxidant activities.

Botany Monoecious, annual or short-lived perennial herb, trailing or climbing with simple tendrils; stem up to 1.5 m long, angular. Leaves alternate, simple; stipules absent; petiole 0.5–6 cm long, pubescent; blade broadly ovate to orbicular, 1–9 cm × 1–12 cm, deeply palmately 5–7-lobed, lobes 3–5-lobulate. Flowers solitary, unisexual, regular, 5-merous; male flowers with pedicel 1.5–10 cm long, receptacle 2–4.5 mm long, sepals 0.5–1 cm long, petals 1–2 cm long, pale yellow, cream or white, and 3 free stamens; female flowers with pedicel up to 0.5 cm long, receptacle 0.5–1 mm long, sepals narrow, up to 0.5 cm long, petals 0.5–1.5 cm long, and inferior, 1-celled ovary. Fruit an ovoid-ellipsoid berry 2.5–4.5 cm long, tuberculate, bright orange or red, dehiscing with 3

valves, exposing the many seeds embedded in red pulp. Seeds ovate, compressed, 9–12 mm long.
Momordica comprises about 40 species, the majority of which are African. Where *Momordica balsamina* and *Momordica charantia* L. both occur, they are not clearly distinguished by the local population. Hence, many vernacular names apply to both.

Ecology *Momordica balsamina* is widespread throughout the drier parts of tropical Africa. It is mainly found on sandy soils, from sea-level up to 1600 m altitude. It occurs in woodland, wooded grassland, on river banks and in dry river beds.

Management *Momordica balsamina* is mainly collected from the wild, but widely cultivated as well. It is planted close to homesteads, often growing over fences and huts.

Genetic resources and breeding *Momordica balsamina* is widespread and not in danger of genetic erosion. Transfer of genes within the genus is possible, allowing improvement of notably *Momordica charantia*.

Prospects The contradictory reports on toxicity of *Momordica balsamina* plant parts should instil caution when transferring uses from one area to another. As in many other cucurbit species, different types may occur: bitter and toxic as well as non-bitter and edible ones.

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Authors C.H. Bosch

MOMORDICA CHARANTIA L.

Protologue Sp. pl. 2: 1009 (1753).
Family Cucurbitaceae
Chromosome number $2n = 22$
Synonyms *Momordica thollonii* Cogn. (1888).

Vernacular names Bitter gourd, balsam pear, bitter melon, karela, African cucumber (En). Margose, concombre amer, paroka, concombre africain (Fr). Melão de São Caetano, balsamina longa (Po). Karela (Sw).

Momordica charantia – wild and planted

Origin and geographic distribution *Momordica charantia* is native to the Old World tropics, but now pantropical. It was possibly domesticated in India and southern China and is now found naturalized in almost all tropical and subtropical regions. It is an important market vegetable in southern and eastern Asia, e.g. India, Sri Lanka, Vietnam, Thailand, Malaysia, the Philippines and southern China. Local cultivars originally from Asia are cultivated on a small scale in tropical America, and bitter gourd is also cultivated in the southern part of the United States for the Asiatic kitchen. It is a common cucurbit in the wild flora of Africa, occurring almost throughout tropical Africa. It is only occasionally collected from the wild as a vegetable or medicinal plant. It is occasionally cultivated in East Africa mostly by people of Asian origin using Asian cultivars.

Uses Immature fruits of *Momordica charantia* are used in stews and curries, or pickled. They are also stuffed with minced meat. Seeds of more mature fruits must be removed. Bitterness may be reduced by parboiling or soaking, squeezing or mashing in salted water, or by scoring the skin of the fruit and sprinkling it with salt. Young fruits of wild small-fruited types are locally eaten in West Africa as supplementary or emergency food. In Zimbabwe young non-bitter fruits are eaten in salads, in the same way as cucumbers. Mature fruits of wild plants are said to be poisonous to people and domestic animals. In Asia shoot tips are a popular leafy vegetable that is considered very healthy. Some farmers even grow bushy bitter gourd types with small fruits especially for this

purpose.
Bitter gourd tea, made from dried fruit pieces, is a popular health drink in Japan and some other Asian countries. Bitter gourd has numerous medicinal uses. In many African countries the fruit is taken as a purgative and vermifuge, whereas leaves are steeped in water and taken to treat diarrhoea and dysentery. Steeped leaves used as enema are said to have strong astringent properties. The seed is used internally as an anthelmintic, especially in DR Congo. In West Africa the plant is used as a febrifuge either by washing or drinking. Yellow fever and jaundice are treated by an enema of the entire plant in water or eye instillation of leaf sap. The plant is used as an aphrodisiac and in local treatment of gonorrhoea. Preparations made from stems and leaves are used to treat yaws. A decoction is applied to boils, ulcers, septic swellings and infected feet. Plaster made from pulverized plants is used to treat malignant ulcers, breast cancer and skin parasites such as filaria and guinea worms. The leaves are taken to treat menstrual problems and the roots are used against syphilis and rheumatism and as an abortifacient. Crushed leaves are used together with other drugs to relieve heart problems, e.g. tachycardia. Manifold medicinal uses are also reported from Asia and the Americas, e.g. to treat cancer, diabetes, psoriasis and many infectious diseases. It is especially renowned as a remedy for diabetes mellitus, just by eating it regularly as a vegetable.

Production and international trade Bitter gourd is cultivated in tropical Asia on possibly hundreds of thousands of hectares, but no accurate statistical data are available. In Africa, it is a minor wild and cultivated vegetable, restricted to urban areas with a market for products of the Asiatic kitchen.

Properties Young fruits contain per 100 g edible portion: water 94.0 g, energy 71 kJ (17 kcal), protein 1.0 g, fat 0.2 g, carbohydrate 3.7 g, dietary fibre 2.8 g, Ca 19 mg, Mg 17 mg, P 31 mg, Fe 0.4 mg, Zn 0.8 mg, vitamin A 380 IU, thiamin 0.04 mg, riboflavin 0.04 mg, niacin 0.40 mg, folate 72 μg, ascorbic acid 84 mg. Fresh leaves contain per 100 g edible portion: water 89.3 g, energy 126 kJ (30 kcal), protein 5.3 g, fat 0.7 g, carbohydrate 3.3 g, Ca 84 mg, Mg 85 mg, P 99 mg, Fe 2.0 mg, Zn 0.3 mg, vitamin A 1734 IU, thiamin 0.18 mg, riboflavin 0.36 mg, niacin 1.11 mg, folate 128 μg, ascorbic acid 88 mg (USDA, 2002).
Several proteins that display a variety of pharmacological effects have been isolated from *Momordica charantia*. The proteins α-momorcharin and β-momorcharin, from seeds of *Momordica charantia*, have been found to show a hepatotoxic effect on isolated rat hepatocytes. Several immunotoxins were prepared by linking the type 1 ribosome-inactivating protein momordin I to antibodies specific to various cell lines. Treatment with these immunotoxins significantly inhibits tumour development in vitro. The treatment alone, or in combination with a general cytostatic significantly inhibits tumour development in vivo, e.g. in mice.
The in-vivo antitumour activity of a crude extract from *Momordica charantia* was significant for several types of tumour cells in mice and in humans. It is thought that in-vivo enhancement of immune functions may contribute to the antitumour effects of the extract. Juices expressed from *Momordica charantia* fruits appreciably reduced the incidence of skin tumours in mice. The extracts of the peel, pulp, seed and whole fruit exhibited marked anticarcinogenic activity against mouse skin papilloma genesis when applied topically. MAP30, an antiviral protein (30 kDa) from *Momordica charantia*, may regulate Herpes simplex virus (HSV) replication. It is also capable of inhibiting infection of HIV-1 in T lymphocytes and monocytes, as well as replication of the virus in infected cells. It was found not to be toxic to normal uninfected cells; the peptide is probably unable to enter healthy cells. It exhibits a dose-dependent inhibition of integration of viral DNA into the host chromosomes (HIV-1 integrase), which is a vital step in the replicative cycle of the AIDS virus. Acylglucosylsterols isolated from unripe fruits showed antimutagenic activity. The protein MAP30 has also been shown to control proliferation of cells of some oestrogen-independent forms of human breast cancer both in vitro and in vivo.
Bitter gourd is often used in folk medicine to treat diabetes, and its hypoglycaemic activity has often been confirmed in trials in experimental animals. However, confirmation of its safe and effective use in humans needs further confirmation. A significant number of studies have established the hypoglycaemic activity of bitter gourd: its effect appears to be more acute and transient than cumulative. The fresh aqueous extract of the whole fruit is more effective than dried powder or dietary consumption. Some studies found that the seed also contained hypoglycaemic principles. In most of

the cases where hypoglycaemic activity could not be demonstrated, normoglycaemic animals were experimented upon. The mechanism of hypoglycaemic activity remains unclear. The results of tests on diabetic patients indicated that fresh bitter gourd juice brought about a significant reduction in plasma glucose concentration, and an improvement in the response to an oral glucose load. The effect of fried bitter gourd was not so pronounced, although it was significant. A cumulative and gradual hypoglycaemic effect was found in diabetic patients using the aqueous extract at the end of a 3-week trial. Contradictory to these findings, however, is a study in which bitter gourd, in the form of fresh juice, dried powder or the powder given as a tablet, did not have any beneficial influence on diabetic patients.

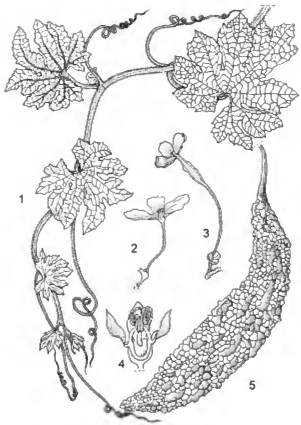
Extracts of *Momordica charantia* were effective in treating *Ascaridia galli* worms in birds. Oral administration of an extract containing 100 mg iron was as effective as a commercial preparation to prevent anaemia in piglets. Chitinase isolated from the fruits may be strongly bacteriostatic.

Momordicines I and II were isolated from dried leaves. These compounds showed antimicrobial activity against several bacteria and fungi. Leaf extracts were also effective against microbes, including *Escherichia coli*, *Salmonella paratyphi* and *Shigella dysenteriae*. Seed extracts resulted in high mortality of the nematodes *Meloidogyne incognita* and *Rotylenchulus reniformis*. The petroleum ether extract of *Momordica charantia* was active against the bean weevil *Callosobruchus chinensis*.

Water extracts of the seed have shown abortifacient activity in mice. The seeds and the fruit wall of *Momordica charantia* are reported to contain a resin, a saponin glycoside of the cucurbitacin type, and alkaloids that may cause vomiting and diarrhoea.

Adulterations and substitutes Other wild African *Momordica* species with fruits and leaves consumed as vegetable with a similar bitter taste are *Momordica balsamina* L., *Momordica foetida* Schum. and *Momordica rostrata* A.Zimm. Most wild *Momordica* species have similar medicinal uses.

Description Monoecious annual climbing or trailing herb with stems up to 5 m long; stem ridged, glabrous or hairy; tendrils simple. Leaves alternate, simple; stipules absent; petiole 1.5–7 cm long; blade broadly ovate-reniform or orbicular in outline, 2.5–10 cm × 3–12.5 cm, cordate at base, deeply palmately (3–)5(–7)-lobed, lobes usually sinuate-lobulate, glabrous or pubescent. Flowers solitary in leaf axils, unisexual, regular, 5-merous, with a prominent bract at base of pedicel; calyx with obconic tube and lobes up to 7 mm long; petals free, obovate-lingulate, up to 2 cm long, pale yellow to orange-yellow, 2 with scales inside at base; male flowers with 3 stamens, anthers coherent in centre of flower; female flowers with inferior, ovoid to fusiform, muricate-tuberculate ovary, stigma 3-lobed. Fruit a pendulous broadly ovoid and beaked to attenuate-ellipsoid berry up to 11 cm × 4 cm, but in cultivars up to 45 cm × 9 cm, reddish-orange when ripe, with a paler apex, ornamented with about 8 longitudinal rows of subconical tubercles and many smaller tubercles in between, splitting into 3 valves and exposing the seeds sheathed in sticky red pulp hanging in 2 rows from the faces of each valve; cultivated fruits with smooth to spiny surface, often with rounded knobs in rows between 8–10 lengthwise ridges, but in some cultivars completely spiny



Momordica charantia – 1, leafy shoot; 2, male flower in longitudinal section; 3, female flower in longitudinal section; 4, male flower in cross section with petals removed; 5, fruit.
Source: PROSEA

without ridges. Seeds oblong, c. 10 mm × 5 mm, flattened, white or brown, testa sculptured, margins grooved.

Other botanical information *Momordica* comprises about 40 species, the majority of which are African. The fruits of several wild species are consumed as a vegetable, whereas several others are used in traditional medicine. Wild and cultivated types of *Momordica charantia* have been variously classified (e.g. cultivated: var. *charantia*; wild: var. *abbreviata* Ser. and var. *longirostrata* Cogn.). The cultivated types can better be classified in cultivar-groups and cultivars, but there is as yet no good classification system.

Growth and development Seedlings emerge 5–7 days after sowing, but fresh seed often shows dormancy which is very hard to break and can last for some months. This is also a major problem for seed of improved cultivars. Stem elongation starts after 2 weeks, followed by the development of lateral stems. Flowering starts with male flowers 5–6 weeks after sowing, while female flowers appear 10 days later. Flowering may continue for 6 months. Flowers open early in the morning. Anthers dehisce about two hours before anthesis and optimum viability of pollen and receptivity of the stigma are attained at anthesis. Flowers are pollinated by bees and other insects. Young fruits can be harvested 10–14 days after anthesis. Continuous harvesting of all young fruits prolongs crop duration. Fruits left on the plant turn orange or yellow 25–30 days after fruit set.

Ecology Bitter gourd prefers quite high temperatures, 25°C and above, but when temperatures become too high (>37°C) fruit set often becomes a problem, depending on genotype. In India cultivars are known, called 'heatset', that will still set fruit at 40°C. Bitter gourd occurs naturally in areas up to 1700 m altitude with a high rainfall, in rainforest, riverine forest, elephant-grass thickets and plantations. If cultivated in too wet conditions, bacterial and fungal wilt and fruit cracking can become major problems, resulting in a lower percentage of high-quality fruits and a shortened shelf life of the fruits. In Asia many farmers grow the crop in the cool and dry season, which may give good results. Still, bitter gourd is not easy to grow. Many farmers use mulch to keep soil moisture conditions balanced. Bitter gourd prefers deep well-drained sandy loam or silt loam soils with a high organic matter content and water-retaining capacity. It seems to be almost day-neutral.

Propagation and planting Bitter gourd is often sown directly. The weight of 1000 seeds of cultivated types is 180–200 g. Seed of wild types may be smaller. Farmers need about 3 kg seed per ha for direct sowing. In South-East Asia farmers often raise seedlings of hybrid cultivars in pots for transplanting at a wide spacing; they then use 1.2–1.5 kg seed per ha. The use of pre-germinated seeds, soaked in moist cloth or tissue overnight or until radicle appearance, results in better plant establishment. Spacing is 50–60 cm in the rows and 120–250 cm between the rows; final plant density is 6,000–20,000 plants per ha, depending on cultivar and trellis system. Planting is generally done on raised beds to prevent waterlogging.

Management The plants are often supported by poles or trellises so that the fruit does not come into contact with soil. Asian farmers use trellises up to 2 m tall, constructed from stakes with a system of horizontal wires and vertical strings. In India, however, farmers rarely use trellises. In the Philippines they are only used for long-fruited types, not for traditional local types. The soil is mulched with rice straw or plastic mulch. Compost manure is usually added to each planting hole before sowing. A dose of 10 t/ha is recommended, together with 200 kg/ha NPK fertilizer, applied before sowing. Additional nitrogen fertilizer may be applied during crop growth, 100 kg/ha N when the plants begin to spread and 200 kg/ha when the plants begin to flower. Irrigation is practised when needed to maintain soil moisture. Bitter gourd is quite sensitive to lack of micronutrients such as boron; application of these elements can strongly improve crop results for farmers.

Diseases and pests Bitter melon is susceptible to several diseases and pests that affect other cucurbits. It is a host of papaya ring spot virus (PRSV-W), and less frequently of watermelon mosaic virus (WMV). Gemini viruses may cause serious problems. A new virus disease called cucurbit aphid-borne yellows was observed in the Philippines and is spreading in South-East Asia. Seedborne viruses are not reported. Some fungal diseases cause serious damage. Cercospora leaf spot (*Cercospora citrullina*) is controlled by pruning of affected leaves and by spraying fungicides such as benomyl, cupravit or daconil. Downy mildew (*Pseudoperonospora solanacearum*) is controlled by wide spacing giving good ventilation and by fungicides such as maneb, ridomil or dithane. Powdery mildew (*Erysiphe cichoracea-*

rum) can be controlled with the same fungicides or with sulphur dust. Commercial cultivars show various degrees of tolerance to these fungal diseases. Bitter gourd is susceptible to bacterial wilt including *Ralstonia*, fusarium wilt, and root-knot nematodes. Fusarium wilt will usually show clear yellowing of the veins, resulting in a 'webbed' pattern on the leaves, before wilting. Infection with bacterial wilt causes quite sudden wilting while the plant is still green. In Taiwan bitter gourd is grafted on a rootstock of pumpkin, smooth loofah or bottle gourd, not only to increase vigour and yield, but also to protect against soilborne wilting diseases and nematodes.
The main pests include aphids and fruit flies (*Dacus cucurbitae*). Heavy aphid infestation can lead to strongly stunted growth and reduced fruit set. Other pests are leaf beetles (*Epilachna* spp.), caterpillars (*Spodoptera* spp., *Heliothis armigera*) and mites.

Harvesting Harvesting starts about 2 months after sowing and is done 2–3 times per week during 2–3 months. It is important to harvest each fruit at the right moment, some days to weeks before reaching full maturity, when they have the right size, the skin is still hard and not turning to yellow-orange, and the seeds are still soft. Beyond this stage, the fruits become spongy and more bitter and lose their market value. The length, diameter and weight depend on cultivar and consumer preference. Regular harvesting is needed as mature fruits on the plants reduce the setting of new fruits.

Yield Average yields of bitter gourd are 8–10 t/ha, but up 20 t/ha for open-pollinated cultivars has been reported. In Thailand hybrid cultivars under good management yield up to 40 t/ha. The number of fruits per plant depends largely on the cultivar used; it can range from around 5 to more than 100; the higher number only in small-fruited cultivars.

Handling after harvest The fruits should be handled and packaged with care, and should be isolated from fruits that produce large amounts of ethylene to prevent post-harvest ripening. Bitter gourd fruits can be stored for a long time, up to 4 weeks at 1–2°C and 85–90% relative humidity. They are chilling sensitive and should not be kept below 0°C. Fruits stored at temperatures above 10°C turn yellow, split open and lose quality.

Genetic resources Local cultivars of bitter gourd are on the verge of extinction as they are being replaced by commercial ones. Collections are available at NBPGR, New Delhi, India, at AVRDC, Taiwan, at Kasetsart University, Thailand and several other research institutes in tropical Asia.

Breeding Most of the cultivars used in East Africa are imported from Asian countries. Wild and cultivated plants cross readily and there are many intermediate types. Wild African types can be exploited as potential source of disease resistances. Breeders nowadays concentrate on F_1 hybrids, the advantages of higher yield potential, better resistance to diseases and more uniformity being obvious. Important selection criteria are earliness, a high ratio of female flowers, resistance to pests and diseases, and degree of bitterness. A high dry matter content is needed for fruits that are cut in pieces and dried. These are sold and used to make bitter gourd tea. No breeding work is reported from African countries.
In tropical Asia many local and improved cultivars are known, with fruit shapes, colours and sizes ranging from the small, spined, dark green semi-wild type to the improved large-fruited cultivars, with colours varying from dark green to pale green and white. East-West Seed Company, in Thailand, the Philippines and Indonesia, has released about ten hybrid cultivars, which show among them a large variation, especially in earliness (first harvest 37–52 days after sowing) and fruit characters (smooth to spined, white or pale green to dark green, spindle-shaped to cylindrical or conical, 6–40 cm long, 2–9 cm broad, weighing 60–650 g). Excellent hybrids especially developed for difficult lowland conditions include 'Ravana' (long, smooth, dark green fruits), 'Palee' (long, spiny, dark green fruits) and 'Indra' (short, spiny, medium green fruits). For growing during the rainy season, when prices for produce are usually high, the cultivar 'Jade Star XL' was developed, which has minimum problems with fruit cracking. For advanced farming systems and shorter crop cycles, earlier maturing pale green cultivars such as 'Hanuman' (medium-sized fruits) and 'Torapi' (long fruits) were introduced. Taiwanese and Indian seed companies also developed F_1 hybrids. The Taiwanese seed company Known-You developed the popular white-fruited warty cultivar 'High Noon' and the green smooth cultivar 'Moonrise'. Bitter gourd has been successfully crossed with *Momordica cochinchinensis* (Lour.) Spreng. and with snake gourd (*Trichosanthes cucumerina* L.). Genetic information on bitter gourd is rather limited; most of this work is done at Indian research institutes.

Prospects In view of the popularity of bitter gourd in the Asian tropics and the release of superior F_1 hybrid cultivars, its popularity in Africa is expected to increase. Since the results with bitter gourd in the treatment of diabetes are still somewhat contradictory, more research needs to be done on its hypoglycaemic activity. Several compounds from bitter gourd show interesting pharmacological activities, e.g. antitumour, immunotoxic and anti-HIV, which merit further research, and may have potential in the development of future medicines.

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Sources of illustration Reyes, M.E.C., Gildemacher, B.H. & Jansen, G.J., 1993.

Authors G.N. Njoroge & M.N. van Luijk

MOMORDICA FOETIDA Schumach.

Protologue Beskr. Guin. pl.: 426 (1827).

Family Cucurbitaceae

Vernacular names Mnukia muuma (Sw).

Origin and geographic distribution *Momordica foetida* is widespread in tropical Africa and in South Africa.

Uses The leaves of *Momordica foetida* are collected from the wild and eaten after boiling as a vegetable in Gabon, Sudan, Uganda, Tanzania and Malawi. They seem fairly unpopular and are eaten in small quantities only, usually in times of scarcity. The pulp of ripe fruits is eaten in Ghana, Gabon, Sudan, Kenya, Uganda and Tanzania.

The plants are grazed by cattle in Sudan. Leaves are used as fodder (Kenya, Tanzania) and are said to be especially suitable for fattening rabbits. However, there are reports from Kenya that cattle avoid it and that it is poisonous. Traditional medicinal uses are numerous and many are shared with other *Momordica* spp. The juice of crushed leaves is used to relieve cough (Uganda), stomach-ache (Uganda), intestinal disorders (Nigeria, South Africa), headache (Burundi, Uganda, Malawi), earache (Tanzania), toothache (Uganda) and as an antidote for snakebites (Tanzania). Skin problems caused by smallpox (Côte d'Ivoire), boils (South Africa), spitting cobra poison and malaria are treated with crushed leaves. The plant is further used as emmenagogue (Côte d'Ivoire), ecbolic (Côte d'Ivoire, Gabon, Uganda, Tanzania), aphrodisiac (Côte d'Ivoire) and abortifacient (Uganda).

The roots, said to be poisonous, and the crushed seeds are used in East Africa to cure constipation. The fruit pulp is said to be poisonous to weevils, moths and ants, and is used as an insect repellent in Tanzania. The Karamajong (Uganda) use the whole plant on their cattle as an oxpecker repellent. The fruits are often eaten by egg-eating snakes. In Gabon the leaves are soaked, dried in the sun and used to stuff cushions.

Properties Leaves have a bitter taste and foetid smell when crushed. Their nutritional composition per 100 g edible portion is: energy 92 kJ (22 kcal), protein 3.3 g, fibre 3.2 g, Ca 1.1 mg, Fe 3.4 mg, Zn 0.4 mg, β-carotene 5.4 mg, folate 40 µg, ascorbic acid 20.6 mg (Nesamvuni, C., Steyn, N.P. & Potgieter, M.J., 2001). Triterpenes of the cucurbitacin type, found in both *Momordica charantia* and *Momordica foetida*, particularly in the fruits and seeds, are potentially cytotoxic. Momordicines and foetidin (identical to charantin) were reported from fruits and leaves of *Momordica foetida*. Momordicines have been found to be both bacteriostatic and insecticidal; foetidin was shown to lower blood glucose levels in normal rats, but it had no significant effect in diabetic animals. Foetidin has slight antispasmodic and anticholinergic effects.

Botany Dioecious, perennial herb, trailing or climbing with simple or bifid tendrils; stem up to 4.5 m long, with dark green flecks when young, woody when old, rooting at the nodes. Leaves alternate, simple; stipules absent; petiole 1.5–17 cm long; blade broadly ovate-cordate to triangular-cordate, 1.5–16 cm × 1.5–17 cm, base deeply cordate. Flowers unisexual, regular, 5-merous; calyx with obconic tube and lobes up to 11 mm long; petals free, obovate-lingulate, up to 3.5 cm long, white, pale yellow to orange-yellow, 3 with scales inside at base; male flowers 1–9 together in fascicles on pe-

duncle 2–23 cm long, with 3 stamens, anthers coherent in centre of flower; female flowers solitary in leaf axils, with inferior, ovoid ovary, stigma 3-lobed. Fruit a long-stalked, ellipsoid berry up to 7 cm × 5 cm, orange when ripe, densely and softly spiny, dehiscing with 3 valves and exposing the many seeds embedded in scarlet pulp. Seeds oblong, flattened, c. 1 cm long, brown, testa sculptured, margins 2-grooved.

Momordica comprises about 40 species, the majority of which are African. The fruits and leaves of several wild species are consumed as vegetables, whereas others are used in traditional medicine.

Ecology *Momordica foetida* occurs in forest edges and clearings, margins of swamps and on disturbed ground as a weed and colonizer, up to 2400 m altitude. In West Africa it is considered an indicator of soil suitable for growing cacao.

Genetic resources and breeding *Momordica foetida* is widespread and not in danger of genetic erosion. A few accessions of *Momordica foetida* are held at the New York State Agricultural Experiment Station (United States) and in the National Genebank of Kenya.

Prospects The main interest in *Momordica foetida* at present appears to lie in the medicinal aspects. The insecticidal properties are only recognized in a small area within its range of distribution. It will remain only a locally used vegetable, but it may become important as a source of resistance in breeding of *Momordica charantia*.

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Authors C.H. Bosch

MOMORDICA ROSTRATA A.Zimm.

Protologue Cucurbitac. 2: 84, 115 (1922).

Family Cucurbitaceae

Chromosome number $2n = 22$

Vernacular names Mtunda nyoka (Sw).

Origin and geographic distribution *Momordica rostrata* occurs in southern Ethiopia, Kenya, Uganda and Tanzania.

Uses The leaves and fruits of *Momordica rostrata* are collected from the wild, boiled and eaten as a vegetable in Kenya and Tanzania. Tender leaves are cooked alone or with other vegetables such as amaranth or peas. Coconut milk or pounded groundnuts may be added and the dish is served with stiff maize porridge or rice. The juicy pulp of the ripe fruit is sweet and edible, but has emetic and laxative properties. The leaves are used in the treatment of malaria. A powder is obtained from the roots by peeling, drying and crushing. It is used as a preservative of stored grain and to kill stem borers in cereal crops. The leaves and stems serve as fodder, in Kenya especially for donkeys.

Properties The nutritional composition of the leaves is unknown, but probably comparable to that of *Momordica charantia* L. Cyanogenic glycosides have been isolated from *Momordica rostrata* shoots and saponins from unspecified plant parts.

Botany Dioecious, perennial herb, trailing or climbing with simple tendrils; stem up to 7 m long, becoming woody with grey bark. Leaves alternate, pedately (5–)9(–12)-foliolate; stipules absent; petiole up to 2.5 cm long; central leaflet elliptical to almost circular, 1–4.5 cm × 1–3 cm, lateral leaflets smaller. Flowers unisexual, regular, 5-merous; male flowers in axillary, 1–14-flowered, umbel-like clusters with peduncle up to 10 cm long, sepals triangular, 2–4 mm long, petals oblong, 7–13 mm long, rounded, pale orange-yellow, stamens 3, free; female flowers solitary, subsessile, sepals triangular-lanceolate, 1.5–2 mm long, petals c. 8 mm long, ovary inferior, narrowly ovoid. Fruit an ovoid berry 3–7 cm × 1.5–3 cm, beaked, rounded or slightly 8-angled, bright red, with many seeds embedded in yellow pulp. Seeds broadly ovate, c. 14 mm long, testa sculptured.

Momordica comprises about 40 species, the majority of which are African.

Ecology *Momordica rostrata* occurs in dry woodland, wooded grassland and on river banks. It is found from sea-level up to 1650 m altitude.

Genetic resources and breeding *Momordica rostrata* is common in at least part of its distribution area, e.g. in Tanzania, and no threats are envisaged.

Prospects *Momordica rostrata* is likely to remain a locally popular vegetable. It may come to play a role in breeding programmes of *Momordica charantia*.

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Other references Jeffrey, C., 1967; Jeffrey, C., 1979; Kameswaro Rao, C. & Wadhawan, S., 2002.

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MORINGA OLEIFERA Lam.

Protologue Encycl. 1(2): 398 (1785).

Family Moringaceae

Chromosome number $n = 11$, $2n = 28$

Synonyms *Moringa pterygosperma* Gaertn. (1791).

Vernacular names Drumstick tree, ben oil tree, horseradish tree (En). Ben ailée, moringa ailée, pois quénique, néverdié (Fr). Muringueiro (Po). Mzunze, mronge, mlonge (Sw).

Origin and geographic distribution *Moringa oleifera* is indigenous in northern India and Pakistan. It has been introduced throughout the tropics and subtropics and has become naturalized in many African countries.

Uses Whereas in Asia the fruits are the most important part of *Moringa oleifera*, the leaves are preferred in Africa. The leaves are eaten as a salad, cooked, and in soups and sauces. Flowers are sometimes eaten as a vegetable, added to sauces or used to make tea. In Sudan the flowers are made into a paste by crushing and then fried. The young fruits are eaten as a vegetable, older fruits are added to sauces. In West Africa some health projects fight malnutrition quite successfully by promoting a number of measures including the use of *Moringa oleifera* leaf powder in the diet of children and pregnant and lactating women. The tuberous root cores can be a substitute for horseradish (*Armoracia rusticana* Gaertn., B.Mey. & Scherb.).

Moringa oleifera – planted

The whole or pounded seeds have long been used to purify water in Sudan, and this practice is promoted elsewhere in Africa. The seed cake, a residue from oil extraction, can also be used for water purification.

The fried seeds are eaten in Nigeria and are said to taste like groundnuts. The seeds are added locally to sauces for their bitter taste. The seed oil, known as 'Ben oil' or 'Behen oil', can be used for cooking, in hair-dressing, as a lubricant and in the perfume industry as a base for fragrant volatile compounds in perfumes. 'Moringa acid oil', consisting of fatty acids from the seed oil, is used as a lubricant and to make soap.

Almost all parts have traditional medicinal applications. Especially the uses as an anodyne, anthelmintic, antispasmodic and disinfectant (bactericidal, fungicidal) are widespread. The bark exudes a white to reddish gum ('Ben gum' or 'Moringa gum') with the properties of tragacanth (*Astragalus*) oil, which is used for tanning, in calico printing and is sometimes added to sauces to make them thicker.

Moringa oleifera is used for living fences, in alley cropping and as a source of nectar for bees. The leaves are eaten by livestock, especially goats, camels and donkeys. The seed cake is considered unsuitable as animal feed because of the high content of alkaloids and saponins and is mainly used as fertilizer. The soft wood burns smoke-free and yields a blue dye. In India its pulp has been used to make paper.

Production and international trade In Africa local trade is mainly restricted to the leaves. In Kenya, some 2000 mostly small-scale farmers produce *Moringa oleifera* green fruits for the Asian community. In Tanzania an enterprise has started with the aim of producing oil and a flocculating agent. There is considerable international trade, mostly from India, in canned and fresh fruits, oil, seeds and leaf powder, but statistics on the volumes and value are not available.

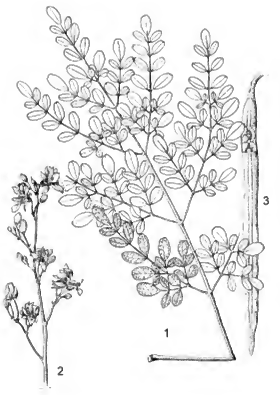
Properties The leafy tips of *Moringa oleifera* contain per 100 g edible portion: water 78.7 g, energy 268 kJ (64 kcal), protein 9.4 g, fat 1.4 g, carbohydrate 8.3 g, total dietary fibre 2.0 g, Ca 185 mg, Mg 147 mg, P 112 mg, Fe 4.0 mg, Zn 0.6 mg, vitamin A 7564 IU, thiamin 0.3 mg,

riboflavin 0.7 mg, niacin 2.2 mg, folate 40 μg, ascorbic acid 51.7 mg. The raw fruits contain per 100 g edible portion: water 88.2 g, energy 155 kJ (37 kcal), protein 2.1 g, fat 0.2 g, carbohydrate 8.5 g, total dietary fibre 3.2 g, Ca 30 mg, Mg 45 mg, P 50 mg, Fe 0.4 mg, Zn 0.4 mg, vitamin A 74 IU, thiamin 0.05 mg, riboflavin 0.07 mg, niacin 0.6 mg, folate 44 μg, ascorbic acid 141.0 mg (USDA, 2003). The dry seeds contain on average: protein 29%, fibre 7.5% and oil 36–42%; of the total fatty acid content oleic acid 65–75%, behenic acid 9%, palmitic acid 9%, stearic acid 7% and small amounts of lignoceric acid and myristic acid. The oil is clear and odourless and does not become rancid quickly. Seeds of *Moringa oleifera* contain a glucosinolate that on hydrolysis yields 4-(α-L-rhamnosyloxy)-benzyl isothiocyanate, an active bactericide and fungicide. The seeds of *Moringa oleifera* yield a lower amount (4–5% of dry weight) of glucosinolate than those of *Moringa stenopetala* (8–10% of dry weight) and should therefore be used at a higher dosage. This isothiocyanate gives the crushed seeds the pungent horseradish smell. Glucosinolates are of interest for human health as their hydrolysis metabolites have both positive (e.g. anti-carcinogenic) and negative (e.g. toxic) effects. The seed contains a protein (cationic polyelectrolyte) that acts as a flocculant in water purification. It also contains a non-protein flocculant that is more effective in purifying low-turbidity water. A number of compounds with medicinal properties have been isolated. The fruit and leaf contain oxalic acid, the bark moringinine, the stem vanillin, the flower kaempferol and quercetin and the root spirochin and pterygospermin.

The wood is white and soft, and has a specific gravity of 0.27.

Adulterations and substitutes *Moringa oleifera* and *Moringa stenopetala* (Baker f.) Cufod. have many characteristics in common. Uses as a vegetable and water purifier are similar. They share several medicinal uses and both have high contents of oil in the seeds. *Moringa oleifera* has a faster development and yields fruits and seeds quickly. *Moringa stenopetala* is better suited to a drier climate; yields of seeds are higher with a higher yield of coagulant. *Moringa peregrina* (Forssk.) Fiori, the Ben-oil producer of ancient Egypt, produces seeds with similar oil content and has several medicinal uses as well.

Description Deciduous to semi-evergreen shrub or small tree up to 10 m tall; trunk up to 45 cm in diameter; bark whitish, grey or pale buff, smooth or rarely rugose, corky; young shoots purplish or greenish white, puberulous. Leaves alternate, 6.5–60 cm long, 2–3-pinnate, with 4–6 pairs of pinnae; stipules absent, but petiole with stipitate glands at base; leaflets elliptical to obovate, 0.5–2(–3) cm × 0.3–1.3(–2) cm, rounded to cuneate at base, apex rounded to emarginate. Inflorescence a spreading, many-flowered panicle 8–30 cm long. Flowers bisexual, zygomorphic, 5-merous; sepals free, 7–14 mm long, often unequal; petals free, oblong-spatulate, 1–2 cm long, unequal, the largest erect, velvety pubescent, white or cream; stamens 5, filaments 7–8 mm long, anthers waxy yellow or orange, alternating with 3–5 staminodes; ovary superior, stalked, cylindrical, 3–5 mm long, pink at base, densely hairy, 1-celled, style slender, glabrous, without stigmatic lobes. Fruit an elongate 3-valved capsule 10–50 cm long, 9-ribbed, brown when ripe, many-seeded. Seeds globose, 1–1.5 cm in diameter, with 3 thin wings 0.5–2.5 cm long.



Moringa oleifera – 1, leaf; 2, inflorescence; 3, fruit.
Source: PROSEA

Other botanical information *Moringa* is the only genus of the *Moringaceae*, a family related to *Brassicaceae*. It comprises 13 species, of which 8 are endemic to the Horn of Af-

rica. *Moringa oleifera* is most closely related to *Moringa concanensis* Nimmo (also from India) and *Moringa peregrina* (Forssk.) Fiori (from the region around the Red Sea, the Horn of Africa, Yemen and Oman). These 3 species share a slender tree habit and the zygomorphic flowers.

Growth and development Germination rates for fresh seeds are around 80%, going down to about 50% after 12 months storage, but no seeds survive 2 years of storage. Initially the tree grows at a remarkable rate; 3–4 m growth in a year is not unusual. Young trees raised from seed start flowering after 2 years. In trees grown from cuttings the first fruits may be expected 6–12 months after planting. Flowering often precedes or coincides with the formation of new leaves. In Nigeria flowering occurs throughout the year.

Ecology *Moringa oleifera* grows well at lower elevations. In East Africa it is found up to 1350 m altitude, but its adaptability is shown by a naturalized stand at over 2000 m in Zimbabwe. It is drought tolerant and is found in locations with as little as 500 mm annual rainfall. It can be grown in a wide range of soils but fertile, well-drained soils are most suitable. Light frost is tolerated.

Propagation and planting In Africa *Moringa oleifera* is mostly propagated by seed; in India the use of cuttings is more common as trees raised from seed produce inferior fruit. Seed is either sown directly in the field at the onset of the rainy season or in an irrigated nursery during the dry season. It is sown at a depth of 2 cm. Germination takes (3–)7–14 days and seedlings benefit from shade (about 50%). Initially they are watered twice a day, but this is reduced to once a day when seedlings are 10–15 cm tall. Seedlings grow to 15–25 cm in 2 months; after 3 months they are 40 cm tall and ready for planting out. Planting out should coincide with the onset of the rains. Manure is applied in each hole.

Cuttings are primarily used for the establishment of live fences. Branches 1–1.5 m in length with a diameter of up to 4 cm will root readily in just a few months. When grown as a short-duration crop in monoculture *Moringa oleifera* is planted at a spacing of 0.7–1 m; when planted for long-term production a common spacing is 3–5 m either way. In Tanzania *Moringa oleifera* is grown for the production of seed for oil and flocculant at a recommended density of 800 trees per ha. In alley cropping an intra-row spacing of 2 m is used. In the wet season cereals are grown between the lines, in the dry season vegetables.

Management *Moringa oleifera* usually receives little care apart from watering. If planted during the dry season half-shade should be provided and watering should be done regularly until the trees are established. Manure application is essential to obtain good yields. Manure is spread over the whole field, so associated crops benefit too. Some farmers apply chemical fertilizers, mainly NPK (e.g. 15–15–15) and urea, but only at the base of the trunk. Pollarding, coppicing and lopping or pruning are recommended to promote branching, increase production and facilitate harvesting. Because its shade can be controlled well *Moringa oleifera* is suitable for planting in alley cropping and in vegetable gardens. When trees reach 1.5 m, farmers prune them (at 50 cm from the ground or at ground level for older ones) once or twice a year. A second pruning usually takes place before ramadan because demand and prices are high during that period. After pruning, it takes about 3 weeks till leaves can be harvested. Pruned poles are used for fences around fields or houses, or to build corrals. Weed control is done manually with a hoe. In Niger *Moringa oleifera* has become so important that it is grown as a field crop.

Diseases and pests In Niger caterpillars are the main pest of *Moringa* and timely pruning provides some control. Termites may be a problem locally. The tree is not seriously affected by diseases in India. Root-rot, related to poor drainage and caused by *Diplodia* sp., has been observed. The hairy caterpillar *Eupterote molifera* can cause defoliation and requires spraying to control it. Other pests include aphids, other caterpillars (e.g. *Heliothis armigera*), a scale insect, a borer and a fruit fly.

Harvesting In Niger harvesting of leaves starts two and a half months after sowing. Leaves are pulled from the branches, then put in bags and transported to the market. Harvesting is done twice a month. Harvesting of green fruits may start 7 months after planting; harvesting of dry fruits for seed about 6 weeks later.

Yield Leaf production in Niger is highest during the rainy season, when a plot of 1000 m^2 yields 13–14 bags per harvest, which amounts to about 27 bags or 600 kg per month. In the dry season monthly yields drop to 2–4 bags in the cool months and to 10–15 bags during the warmer months if irrigated. This is equivalent to an annual production of 27 t/ha

fresh leaves. In Tanzania the seed yield of a 4-year-old tree is about 3.3 kg. In India a good tree yields 1000 fruits.

Handling after harvest Leaves can be dried and stored. Powdering the leaves before storing is locally common. Stored seeds are susceptible to insect damage and require protective measures.

Genetic resources Most genetic variation in *Moringa oleifera* is found in north-western India, but in the wild it is probably extinct. As it is a cross-pollinated tree, high heterogeneity in form and yield is common. Research into genetic variation in populations from Kenya, Malawi and India concluded that germplasm from at least two sources has been introduced into Kenya. The high levels of population differentiation suggest that provenance source is important in the conservation and exploitation of genetic resources. The species is widespread in the tropics and subtropics and there are numerous accessions in genebanks, e.g. in the Centre National de Semences Foresti res (CNSF), Ouagadougou, Burkina Faso. In the Philippines, where the leaves are popular, a sizeable collection is maintained at the National Plant Genetic Resources Laboratory, IPB/UPLB, College, Los Baños.

Breeding No breeding work has been undertaken in Africa. In India 'Jaffna' types are popular for their long fruits (60 cm to more than 1 m long). In India a short-stem type of *Moringa oleifera*, released as PKM1, has also been developed for the production of immature fruits. Many farmers grow this type as an annual (two harvests per year). For Africa the most important selection criteria would be high leaf yield, whereas selection and breeding have so far concentrated on optimizing fruit yield. There is potential for hybridization with other *Moringa* species. *Moringa stenopetala* contains flocculating agents similar to those in *Moringa oleifera* and produces bigger seeds, so it may be possible to increase yields by hybridization with this species. It may be possible to increase the oil yield of *Moringa oleifera* by producing hybrids with *Moringa peregrina* (Forssk.) Fiori, which has higher oil content (c. 50%). So far, no results of hybridization trials have been published.

Prospects *Moringa oleifera* is likely to become an even more important multipurpose crop in Africa than it is at present. Research interest in several *Moringa* species is enormous. The use as a low-cost water purifier is highly valuable for sanitary improvement in remote villages. Cultivar selection and the development of hybrids have great potential. Many of the local medicinal applications are not fully substantiated by pharmacological research and warrant further research. The industrial demand for *Moringa* oil is likely to increase as novel applications are developed.

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Sources of illustration Polprasid, P., 1993.

Authors C.H. Bosch

MORINGA STENOPETALA (Baker f.) Cufod.

Protologue Senckenberg. Biol. 38: 407 (1957).

Family Moringaceae

Vernacular names Cabbage tree, African moringa tree (En).

Origin and geographic distribution *Moringa stenopetala* is endemic to East Africa, where it occurs in northern Kenya and in Ethiopia. In Ethiopia it is widely cultivated. The cultivated trees may have been derived from a wild population at Chew Bahir (Lake Stephanie), which is now extinct. *Moringa stenopetala* is presently only known in the wild from five localities, all in northern Kenya. Records for Djibouti and Somalia are probably based on misidentifications or on recent introductions, and records from Sudan and Uganda probably refer to cultivated specimens. In recent years *Moringa stenopetala* has been dispersed and promoted in many tropical countries, e.g. Senegal and Malawi.

Uses In Konso (Ethiopia) the leaflets of *Moringa stenopetala* are separated from the rachis

Moringa stenopetala – wild

and plunged into boiling water. Salt or sodium carbonate is added to the water. While the leaves are cooking, a mixture of flours is prepared, then kneaded and made into balls 2–5 cm in diameter. These are tossed into the water as well and after about 10 minutes the balls and the leaves are ready to serve. The addition of fat (grease or butter), small-sized cereal balls and a large amount of leaves are considered to make this dish a good-quality meal. Young, soft fruits can also be added, but the slightly bitter taste restricts the use to periods when food is in short supply. During the dry season the average consumption of leaves by adults in southern Ethiopia is 150 g/day, corresponding with 19% of the energy and 30% of the protein requirement. Over 5 million people consume *Moringa stenopetala* as a vegetable.

Moringa stenopetala has many other uses. The Turkana people of northern Kenya make an infusion of the leaves, which is used as a remedy against leprosy. The Njemp people in Kenya chew the bark as a treatment against coughs, and use it to make fortifying soups. In the Konso area of Ethiopia the smoke of burning roots is used as a treatment for epilepsy and the leaves of certain *Moringa stenopetala* trees are renowned for their effectiveness against diarrhoea. In the Negelle and Wolayeta Sodo areas (Ethiopia) the leaves and roots are used as a cure for malaria, stomach problems and diabetes. The leaves are also used to treat hypertension, retained placenta, asthma, colds, as an anthelmintic, to induce vomiting and to promote wound healing. In Somalia the smoke of burning roots is said to be inhaled by women during difficult labour, but as the species has not been collected so far in Somalia, this record is probably incorrect.

The wood is very soft and useful for making paper, but it makes low-grade firewood and poor-quality charcoal. In the Negelle and Wolayeta Sodo areas the seeds are used to purify water. Although in cultivation the primary goal is vegetable production, the tree can also play a role in erosion control, as a live fence, as a windbreak, for shade and as a bee plant. In Ethiopia the leaves, especially of trees with bitter leaves considered unsuitable for human consumption, and young fruits are fed to livestock. The Turkana people also feed the leaves to their livestock. In some areas of southern Ethiopia the seed oil is used as a lubricant, in perfumery and in soap production.

Production and international trade In local markets in Ethiopia leaves are sold for vegetable use. There seems to be a modest trade in leaves from south-western Ethiopia to Addis Ababa for use as medicine.

Properties The raw leaves of *Moringa stenopetala* contain per 100 g dry matter: energy 1235 kJ (295 kcal), protein 9.0 g, fat 5.8 g, carbohydrate 51.8 g, crude fibre 20.8 g, Ca 793 mg, P 65.6 mg, Zn 0.53 mg, vitamin A 31 IU and ascorbic acid 28 mg (Abuye et al., 2003).

The composition of the seed oil is not well known but likely to be similar to that of *Moringa oleifera*. Analysis of a sample from Uganda indicated fatty acid composition as: palmitic acid 6%, stearic acid 4%, oleic acid 75%, arachidic acid 3%, behenic acid 6%. The unsaturated fatty acids account for 78% of the total. The oil further contained sterols 0.5% (mainly β-sitosterol and Δ^5avenasterol) and tocopherols 200 mg/kg (mainly α-tocopherol, γ-tocopherol, and δ-tocopherol).

Defatted and shell-free seeds of *Moringa stenopetala* contain the glucosinolates 4-(α-L-rhamnopyranosyloxy)-benzyl glucosinolate and glucoconringiin (2-hydroxy-2-methylpropyl glucosinolate). On hydrolysis the former yields 4-(α-L-rhamnosyloxy)-benzyl isothiocyanate, an active bactericide and fungicide. The seeds of *Moringa stenopetala* yield a higher amount (8–10% of dry weight) of the glucosinolate than those of *Moringa oleifera* Lam. and can therefore be used at a lower dosage. The isothiocyanate gives the crushed seeds their pungent horseradish smell. The glucosinolates in the leaves were found to cause goitre but to a lesser extent than expected on the basis of their concentration. However, in a diet poor in iodine it may be a contributing factor. The seed

contains a protein (cationic polyelectrolyte) that acts as a flocculant in water purification. It can be extracted from the ground seed with salt water.
Ethanol extracts of leaves and roots have shown promise in control of *Trypanosoma brucei* and *Leishmania donovani* in in-vitro experiments. The leaf extract causes increased uterine smooth muscle contractions in mice and guinea pigs. The medicinal use of leaves to expel a retained placenta may be related to these increased contractions. A crude seed extract strongly inhibited growth of *Staphylococcus aureus, Salmonella typhi, Shigella* sp. and *Candida albicans*.
The hypoglycaemic effect of an aqueous extract of *Moringa stenopetala* leaves was confirmed in non-diabetic rabbits. In in-vivo experiments the extract and glibenclamide were compared. The plant extract was found to lower blood glucose concentration although it was less potent than glibenclamide. The effect was observed to increase with time and with increasing dose of the extract.

Adulterations and substitutes *Moringa oleifera* and *Moringa stenopetala* have many characteristics in common. Use as a vegetable and water purifier are similar. They share several medicinal uses and both have high contents of oil in the seeds. *Moringa oleifera* has a faster development and yields fruits and seeds quickly. *Moringa stenopetala* is better suited to a drier climate; yields of seeds are higher and they have a higher coagulant content.

Description Small tree up to 10 m tall; trunk up to 100 cm in diameter, swollen, bottle-shaped; bark whitish, pale grey, silvery or blackish, smooth; crown strongly branched; young shoots densely pubescent. Leaves alternate, up to 55 cm long, 2–3-pinnate, with c. 5 pairs of pinnae; stipules absent, but petiole with stipitate glands at base; leaflets elliptical to ovate, 3.5–6.5 cm × 2–3.5 cm, with stipel-like glands at base of stalk, rounded to cuneate at base, apex acute, with thickened apiculum. Inflorescence a dense, many-flowered panicle up to 60 cm long. Flowers bisexual, regular, 5-merous; sepals free, 4–7 mm long, equal, cream flushed pink; petals free, oblong to linear-oblong, 8–10 mm long, equal, with long hairs inside, white, pale yellow or yellow-green; stamens 5, filaments 4–6.5 mm long, anthers yellow, alternating with staminodes; ovary superior, stalked, ovoid, c. 2 mm long, densely hairy, 1-celled, style narrowly cylindrical, glabrous, without stigmatic lobes. Fruit an elongate 3-valved capsule 20–50 cm long, grooved, twisted when young, later straight, reddish with greyish bloom, many-seeded. Seeds elliptical-trigonous, 2.5–3.5 cm × 1.5–2 cm, with 3 thin wings 6–9 cm long.

Moringa stenopetala – 1, part of leaf; 2, part of inflorescence; 3, flower; 4, fruit; 5, seed. Redrawn and adapted by Iskak Syamsudin

Other botanical information *Moringa* comprises 13 species, of which 8 are endemic to the Horn of Africa. *Moringa stenopetala* shares its bottle-shaped trunk with *Moringa ovalifolia* Dinter & A.Berger, found in Namibia and Angola, and with two endemics of Madagascar, *Moringa drouhardii* Jum. and *Moringa hildebrandtii* Engl. These four species also have the small, regular flowers in common. Cladistic evidence, however, suggests that they are not closely related.

Growth and development In experimental plantings of *Moringa stenopetala* in Sudan, plants reached a height of 3 m in 14 months. First flowers appeared 2.5 years after sowing. In Konso the first leaves are harvested after about 3 years.

Ecology The wild populations of *Moringa stenopetala* are found at 400–1000 m altitude in areas with mean annual temperatures of 24–30°C. In cultivation *Moringa stenopetala* is

found at 500–1800 m altitude, but the upper growth limit extends to 2100 m if trees are sheltered from wind and heavy rain. Annual rainfall in the area where it is found in Ethiopia is 500–2400 mm. Light frost is tolerated, but severe frost may cause trees to die back to ground level. In the wild *Moringa stenopetala* usually occurs on rocky ground near permanent water. It prefers well-drained soils with a high groundwater table, yet it also withstands dry conditions well, and consequently it is found in both wetlands and dry areas.

Propagation and planting The recommended way of propagation is by sowing in polythene bags. Seeds of up to 1 year old have a germination rate of close to 100%; germination of older seeds is variable and declines as a function of age and storage method. Seeds are placed 1 cm deep in a mixture of sand and loam, enriched with compost. The bags have to be in half shade and watered daily. Germination rate and speed of germination are highest at 25–30°C. Transplanting can be done when the plants are 20 cm tall or 6 months old, and with proper water supply (about 25 l of water every 3–4 days) all plants should survive. The most common practice in traditional cultivation is to transplant seedlings that have become established under old trees. Before transplanting, branches and roots are cut and the seedlings are left to dry for a week, roots are covered with ash and upper parts with dung. In arable fields in Konso, where food crops such as sorghum, maize and finger millet are grown, 30–50 trees/ha are maintained. In drier areas the trees are planted in micro-catchments. In Arab Minch, trees are mainly grown in home gardens of up to 0.1 ha with 5–15 trees per garden. Other crops usually grown in these gardens are papaya, coffee, banana, cassava, maize, sugar cane, cotton and *Capsicum* peppers.

Cuttings can be used, but in the traditional practice of the Konso people they are seldom used. Trees established from cuttings were found to have a poor root system.

Management Trees are pruned every 5 years during the rainy season (March–April). Ownership of individual trees is well regulated. Even trees in public places are owned by individuals and the right to harvest leaves of a tree for life can be bought and sold.

Diseases and pests The main problem of *Moringa stenopetala* in Konso is an unidentified caterpillar, which, in just a week can devour the leaves of the trees of an entire village. No effective treatment has been found yet. In excessively wet soils root rot occurs.

Harvesting The leaves of *Moringa stenopetala* are preferably left on the trees during the rainy season when other vegetables are in ample supply. Leaves have a better taste in the dry season than during the rains. Harvesting is mainly done by children using a long pole with a sickle-like blade attached. Fruits are harvested young to avoid competition with leaf production.

Yield Yield estimates are scarce. Annual production can reach 2000 fruits or 6 kg of seed per tree under ideal conditions. Medium to high fruit and leaf yields are reported for the plains of the Rift Valley at about 1200 m altitude. At altitudes of over 1650 m no fruits at all are harvested and leaf production is poor.

Genetic resources A single wild population is known from Lake Baringo and 4 populations from around Lake Turkana. Most material used in past research probably came from the Lake Baringo population. In the cultivated trees in south-western Ethiopia there is considerable variation in characteristics. The taste of the leaves differs between trees and ranges from sweet to bitter. Some trees are known to produce leaves that are outstanding for treating diarrhoea. Easy disintegration of the leaves during cooking is also an important characteristic. Selection of seed from trees with good characteristics has been practised in Konso over a long period. Increased seed size of cultivated trees in comparison with wild trees is one of the results of this selection.

The Biodiversity Conservation and Research Institute, Addis Ababa, Ethiopia holds a few germplasm accessions of *Moringa stenopetala*.

Breeding Apart from selection by farmers in Ethiopia, no attempts have been made to improve *Moringa stenopetala*.

Prospects Although the potential of *Moringa stenopetala* has long gone unnoticed, it has recently attracted a lot of attention. In the future, the use of Ethiopian germplasm in research will improve understanding of the variation in taste and chemical composition. For semi-arid climates *Moringa stenopetala* may eventually become an even more important multi-purpose crop than *Moringa oleifera*.

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Sources of illustration Verdcourt, B., 1986; Verdcourt, B., 2000b.

Authors C.H. Bosch

MYRIANTHUS ARBOREUS P.Beauv.

Protologue Fl. Oware 1: 16, t. 11, 12 (1805).

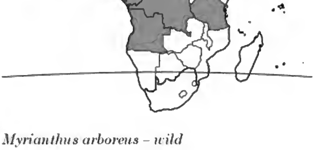
Family Cecropiaceae (APG: Urticaceae)

Chromosome number $2n = 28$

Vernacular names Giant yellow mulberry, bush pineapple, corkwood (En). Grand wounian, arbre à pain indigène (Fr). Pernambuco (Po).

Origin and geographic distribution *Myrianthus arboreus* occurs in the forest zone of tropical Africa from Guinea and Sierra Leone east to southern Sudan and Ethiopia and south to DR Congo, Tanzania and Angola.

Uses In West Africa young leaves are eaten in vegetable soups. In Delta and Edo States of Nigeria, the leaves of *Myrianthus arboreus* are rated among the most popular indigenous vegetables. Throughout the range of the species, the heartshaped fruit, called 'God's heart' in Ghana, is eaten for its sweet or acidulous pulp. The oil-rich seed, which is about 1 cm long, is eaten after cooking from Côte d'Ivoire to DR Congo.



Myrianthus arboreus – wild

Extracts of the leaves or leafy shoots of *Myrianthus arboreus* are used in Sierra Leone, Nigeria and the Mount Cameroon area in preparations to treat dysentery, diarrhoea and vomiting. In the Igala area of Nigeria the leaves are an ingredient of a febrifuge given to young children. In eastern Nigeria a plaster made of beaten leaf-petioles is applied to boils, and the bruised leaf is similarly used in Gabon. In Congo chopped leaves are eaten raw with salt to treat heart troubles, pregnancy complications, dysmenorrhoea and incipient hernia. A bark decoction is drunk to treat malaria, fever and cough. In DR Congo a leaf decoction is also used as an anticough medicine. In Tanzania an infusion of the leaves is taken to improve lactation in women. Sap from young leaves or terminal buds is applied topically to treat toothache or to the chest against bronchitis and to the throat against laryngitis or sore throat. *Myrianthus arboreus* is a useful analgesic in the treatment of muscular pains, fractures and haemorrhoids. In Côte d'Ivoire pounded leaves are applied as an enema to treat pain in the back and loins. The copious sap from the aerial roots is drunk in Congo as an antitussive and antidiarrhoeic, and as a remedy for haematuria and blennorrhoea. The roots are diced and prepared together with melegueta pepper (seeds of *Aframomum melegueta* K.Schum.) as a vapour bath against headache. In Congo the whole fruit is boiled in sap from the tree or in palm wine or other fruit-ferments and taken as an emeto-purgative; the bark or leaves are used similarly but are considered less effective. *Myrianthus arboreus* is important as an auxiliary plant, the leaves forming a thick layer of organic mulch. It is being tested for managed fallow systems.

The wood is soft, yellowish white, perishable and difficult to work, but is used for fencing and occasionally as a general purpose wood. The wood is also suitable for paper making. Its ashes are used in soap making in Guinea. Extracts of *Myrianthus arboreus* deter the termite *Reticulitermes lucifugus*.

Production and international trade No production data on *Myrianthus arboreus* are avail-

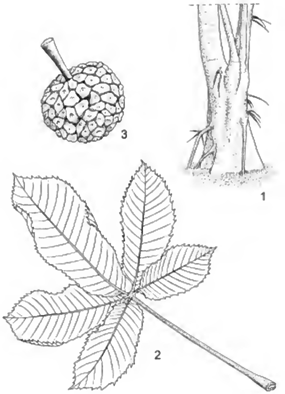
able. The leaves are locally traded. Export trade of the leaves is not reported, but several firms are licensed to export material of *Myrianthus arboreus* for pharmaceutical purposes.

Properties There is no information on leaf composition. The composition of fresh fruit pulp of *Myrianthus* sp. per 100 g edible portion is: water 85.5 g, energy 205 kJ (49 kcal), protein 1.9 g, carbohydrate 11.8 g, Ca 44 mg, P 70 mg, Fe 1.1 mg. The composition of dried seeds per 100 g is: water 13.5 g, energy 1972 kJ (471 kcal), protein 23.6 g, fat 33.4 g, carbohydrate 27.0 g, fibre 3.5 g, Ca 132 mg, P 371 mg, Fe 6.6 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1986). The oil consists almost exclusively of linoleic acid (93%). The protein is rich in the amino acid cystine which is important in a region where chronic deficiency of sulphur-bearing amino-acids occurs.

Several pentacyclic triterpenoids have been isolated from the wood and the roots. Euscaphic acid, myrianthic acid, tormentic acid, ursolic acid and a derivative of ursenoic acid have been isolated from stems. Myrianthinic acid was isolated from the bark. The wood also contains myrianthiphyllin, a lignan cinnamate. Bark extracts of *Myrianthus arboreus* showed antiplasmodial, antimycobacterial and antitrypanosomal effects in vitro, which supports some of its uses in traditional medicine, e.g. to treat malaria.

Description Dioecious shrub or tree up to 14(–20) m tall; bole short, up to 1 m in diameter, often with stilt roots; bark fairly smooth, greyish, thin, slash white; branches spreading. Leaves arranged spirally, palmately compound; stipules up to 5 cm long, amplexicaul, caducous, leaving annular scars; petiole (15–)25–55 cm long; leaflets 5–7, sessile or stalked, lanceolate or oblanceolate, up to 65 cm × 22 cm, margin serrate to dentate, whitish pubescent on veins below, many-veined. Male inflorescences repeatedly branched, up to 30 cm in diameter, consisting of glomerules, with peduncle up to 20 cm long; female inflorescences a globose head up to 3.5 cm in diameter, with peduncle up to 6 cm long. Flowers sessile, small; male flowers with 3–4 tepals and 3–4 stamens; female flowers with 2–3-lobed perianth and superior, 1-celled ovary, stigma tongue-shaped. Fruit drupe-like, with fleshy perianth, yellow to orange-red, 1-seeded, closely arranged in an infructescence up to 10(–15) cm in diameter. Seed up to 12 mm long. Seedling with simple leaves.

Other botanical information *Myrianthus* comprises 7 species and is restricted to tropical Africa. The lowlands of West and Central Africa are richest in species. The leaves of *Myrianthus libericus* Rendle and *Myrianthus serratus* (Trécul) Benth. & Hook. are also occasionally collected as a vegetable, but their edible fruits and seeds seem to be more important as they are for other *Myrianthus* species. The East African *Myrianthus holstii* Engl. is related to *Myrianthus arboreus*, but can be distinguished by its yellow to orange-brown indumentum.



Myrianthus arboreus – 1, bole; 2, leaf; 3, infructescence.
Redrawn and adapted by Achmad Satiri Nurhaman

Growth and development The seeds of *Myrianthus arboreus* are dispersed by animals such as monkeys and birds. Natural regeneration also takes place around the base of trees in forests as well as farmland. During forest clearing for farming, *Myrianthus arboreus* trees are often protected and retained. In an experiment trees started bearing fruit when about 5 years old. In West Africa the trees flower from January to April and bear fruits from February to July, whereas in Central Africa they can be found flowering throughout the year and in Tanzania they flower from November to December and fruits mature from

February to March.

Ecology *Myrianthus arboreus* is a common tree in the forest area of West and Central Africa, occurring in rain forest, semi-deciduous forest, swamp forest, also as a late pioneer species in secondary forest and fallow land, in wet or damp situations and on stream banks. It needs a high annual rainfall. It grows naturally from sea-level up to 1200 m altitude. In Nigeria it is common in the lowland, below 300 m altitude.

Propagation and planting Germination of the seeds takes about 1 month; the germination rate is about 40%, but can be improved by soaking the seed prior to planting. Bud grafting and stem cuttings have been successfully used for propagation in experiments.

Management *Myrianthus arboreus* leaves are collected from wild and semi-wild stands. Protection and retention of trees in farms is common. It is recommended as a fallow species for more remote fields. Through its mycorrhizal associations it has the ability to improve the nitrogen status of the soil.

Harvesting Young tender leaves are plucked when required. A market survey in Enugu (south-eastern Nigeria) indicated availability during February–October. In Tanzania the fruits are picked early in the dry season.

Handling after harvest The leaves of *Myrianthus arboreus* remain fresh for 3–5 days; leafy twigs are brought to the local market soon after harvesting.

Genetic resources The genetic diversity in *Myrianthus arboreus* has not been studied, but there are no indications that serious genetic erosion occurs.

Prospects The leaves and fruits of *Myrianthus arboreus* provide food, especially important during the hunger period before the harvest of other crops. Its myriad medicinal uses indicate that more research into its chemical composition and pharmacological activities is justified.

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Sources of illustration White, L. & Abernathy, K., 1997; Wilks, C. & Issembé, Y., 2000.

Authors J.C. Okafor

NASTURTIUM OFFICINALE R.Br.

Protologue W.T.Aiton, Hortus kew. 4: 111 (1812).

Family Brassicaceae (Cruciferae)

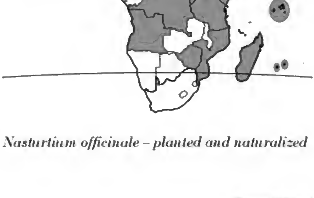
Chromosome number $2n = 32$

Synonyms *Rorippa nasturtium-aquaticum* (L.) Hayek (1905).

Vernacular names Watercress (En). Cresson, cresson de fontaine (Fr). Agrião de água, agrião das fontes (Po).

Origin and geographic distribution Watercress is native in Europe and western Asia, and possibly also in the highland regions of Ethiopia. It has been introduced in many African regions, and is locally naturalized in mainland Africa, Madagascar and other Indian Ocean islands, mainly in mountainous regions. It has been introduced into many other tropical and temperate regions.

Uses Young shoots with leaves are used as a pungent garnish and eaten raw in salads. Watercress is also eaten as a cooked vegetable or made into watercress soups. In Africa it is mainly eaten by expatriate communities. Watercress has a long history as a medicinal plant, used to prevent scurvy. In the United States and Europe it is now a health food used against a wide range of ailments such as itch-



Nasturtium officinale – planted and naturalized

ing of the skin, as antiscorbutic stimulant and as a laxative.

Production and international trade Watercress is locally important in the Western world, but few statistics on production or trade are available. Annual production in the United Kingdom is about 2500 t, but declining. In Africa it is cultivated on a small scale throughout the continent.

Properties The nutritional composition of watercress per 100 g edible portion (large stalks removed, 62% as purchased) is: water 92.5 g, energy 92 kJ (22 kcal), protein 3.0 g, fat 1.0 g, carbohydrate 0.4 g, dietary fibre 1.5 g, Ca 170 mg, Mg 15 mg, P 52 mg, Fe 2.2 mg, Zn 0.7 mg, carotene 2520 µg, thiamin 0.16 mg, riboflavin 0.06 mg, niacin 0.3 mg, ascorbic acid 62 mg (Holland, B., Unwin, I.D. & Buss, D.H., 1991).
Watercress yields a pungent volatile oil containing glucosinolates. Some of these compounds produce anti-carcinogenic compounds on hydrolysis, e.g. phenethyl isothiocyanate, which showed protection against cancers associated with tobacco-specific carcinogens. Flavonols and megastigmanes were isolated showing histamine release inhibiting activity.

Description Perennial creeping or floating, glabrous herb; stem up to 1 m long, hollow, juicy, much branched, with roots on stem nodes. Leaves alternate, up to 10 cm long, without stipules, stalked, pinnate; lateral leaflets in 2–9 pairs, sessile, nearly circular to elliptical or obovate, entire to slightly toothed, terminal leaflet usually larger. Inflorescence a terminal raceme c. 10 cm long, without bracts. Flowers bisexual, 4-merous; sepals c. 2 mm long; petals obovate, c. 4 mm long, white; stamens 6, free, with yellow anthers; ovary superior, 2-celled, style simple. Fruit a broadly linear silique 1–2 cm × 2–3 mm, with many seeds in 2 rows in each cell. Seeds spherical, dark red-brown, reticulate. Seedling with epigeal germination; hypocotyl 7–8 mm long, epicotyl 2–3 mm long; cotyledons stalked, circular, 2–4 mm long, leafy.

Nasturtium officinale – flowering and fruiting branch.
Source: PROSEA

Other botanical information *Nasturtium* comprises 5 species. It is often included in the larger genus *Rorippa*, but molecular data, combined with morphological differences, support the separation from *Rorippa* and show that *Nasturtium* is most closely related to *Cardamine*.
Nasturtium microphylla Boenn. is closely related to *Nasturtium officinale*; it differs in its slightly larger flowers and more slender but longer fruits with seeds in a single row per cell. It is an allotetraploid with $2n = 64$. It occurs naturalized in Africa in similar habitats as *Nasturtium officinale*, and is sometimes also cultivated as watercress.

Growth and development Soon after planting stem cuttings develop roots on the nodes. The strongly branching plants may develop a thick mass of vegetation. In equatorial areas watercress seldom flowers. Under long-day conditions of over 13 hours, watercress flowers profusely when the flow of water becomes stagnant and especially when the water level becomes shallow and the land starts drying. It is self compatible. Watercress can be harvested for several years, but diseases and weeds may necessitate new planting.

Ecology Watercress occurs naturally along running water and grows floating in shallow water. Shallow ponds can rapidly become covered and the species is sometimes considered an inoffensive weed. It is easy to establish a watercress crop wherever conditions are cool and wet. It grows in East Africa at elevations above 500 m. It requires running water for vigorous growth and high yield of tender and sweet shoots. When there is no longer running water, plants become bitter and are no longer suitable for consumption. At higher latitudes in the summer abundant flowering will impede the harvest. Watercress likes sandy or gravelly soils and is rather common in limestone areas, preferring neutral to slightly alkaline water

with pH 6.5–7.5. The water should be rich in minerals and contain 1–4 ppm of nitrate. The water temperature should not exceed 26°C. It can withstand light frost (–2°C). Watercress tolerates polluted soil and water, contaminated by heavy metals, but these can be found as residues in the harvested product. The reduced water current velocities due to watercress appear to be important for the distribution of small invertebrates, creating a variety of living conditions in the water column. Watercress can host river flukes (*Fasciola hepatica*) and bilharzia parasites (*Schistosoma haematobium*, *Schistosoma intercalatum*); its cultivation in uncontrolled water is therefore not recommended. A watercress habitat provides cover and abundant food supply for fish.

Propagation and planting Watercress is usually reproduced from stem cuttings. Reproduction by seed is sometimes practised in temperate areas. Cuttings 10–20 cm long are planted in mud beds at a spacing of 20 cm × 20 cm with frequent irrigation or continuous running water. They root easily in moist sand.

Management Once the crop has been established, only limited attention is given apart from occasional weeding. Most important is the control of water flow, ensuring that the water current does not become too strong. When the water source dries up during the dry season, it is important to irrigate sufficiently to keep the crop alive, allowing an adequate supply of planting material for the next season. Farmers in Arusha (Tanzania) divert local streams to flood small plots of land covered with watercress. Watercress requires plenty of phosphate and nitrate and these should be applied if the nutrient content of the plant bed is low.

Diseases and pests Diseases are rarely a problem in watercress. In Asia the crop may be affected by a virus which spreads when using cuttings only. To overcome this problem seedlings should be planted rather than using cuttings. The seed should be collected from vigorous plants that are free from diseases. In the Caribbean region *Cercospora nasturtii* is recorded as the main disease. Aster yellows transmitted by leafhoppers can be a problem, e.g. in Hawaii. Flea beetles, aphids and caterpillars could affect the crop but with an adequate flow of water they are usually not a problem, especially if farmers can submerge the crop as a control measure.

Harvesting Watercress can be harvested 6–8 weeks after planting and subsequent harvests can be made every 3 weeks for more than a year.

Yield Farmers may collect up to 2 kg/m^2 from the first harvest and up to 1 kg/m^2 from subsequent harvests, but the yield will decline rapidly as the crop senesces, the flow of water reduces or nutrient contents diminish. An annual yield of up to 50 t/ha is easily possible.

Handling after harvest Harvested shoots are tied in bunches and yellow leaves are removed before dispatch to the market. Watercress is perishable and can only be stored at low temperatures and close to 100% relative humidity.

Genetic resources No germplasm collections are known in Africa, but the diversity in naturalized populations is significant.

Breeding Little breeding work on watercress has been done, although some seed catalogues list watercress. In Africa people virtually always use cuttings rather than seeds and no plant breeding activities take place at present.

Prospects The demand for watercress in Africa is becoming lower as the population of European origin declines. Local demand is likely to be satisfied by collection from wild and naturalized *Nasturtium* and *Rorippa* species.

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Sources of illustration Rahmansyah, M., 1993b.

Authors R.R. Schippers

NIDORELLA MICROCEPHALA Steetz

Protologue Peters, Naturw. Reise Mossambique Vol. 6, Botanik 2: 398, 406 (1864).

Family Asteraceae (Compositae)

Synonyms *Nidorella resedifolia* DC. subsp. *microcephala* (Steetz) Wild (1969).

Origin and geographic distribution *Nidorella microcephala* is found in Tanzania, Malawi, Zambia, Zimbabwe, Mozambique and South Africa.

Uses In Malawi the leaves are locally eaten as a vegetable. Availability extends well into the dry season.

Botany Erect, annual herb up to 150 cm tall; stem solitary, rarely branched from the base. Leaves alternate, simple, sessile; blade obovate or spatulate, 2–14 cm × 1–6 cm, gradually narrowed and auriculate at base, apex rounded, sometimes mucronate, margins crenate-dentate in wider part of blade. Inflorescence a head 1.5–2 mm long, arranged in a lax leafy corymb consisting of subglobose cymes of many heads. Flowers bright yellow, ray flowers 35–45, disk flowers 4–9. Fruit an ellipsoid, slightly flattened achene c. 0.5 mm long; pappus up to 1 mm long.

Nidorella comprises about 15 species and is restricted to eastern and southern Africa. Some species have medicinal uses. *Nidorella resedifolia* DC. is very similar to *Nidorella microcephala*, but has larger heads and flowers, and is found at higher altitudes. *Mtonia glandulifera* Beentje superficially resembles *Nidorella microcephala* and occurs in similar habitats; the lack of pappus and the larger number of disk flowers distinguish it.

Ecology *Nidorella microcephala* is found in riverine habitats on sand or clay, as well as in roadside ditches and as a weed in gardens, at 300–1800 m altitude.

Genetic resources and breeding As *Nidorella microcephala* is widespread, obviously not uncommon and not much sought after, no threat of genetic erosion is envisaged.

Prospects Little is known about *Nidorella microcephala* and its use as a vegetable will probably remain unimportant.

Major references Beentje, H.J., 2002; Williamson, J., 1955.

Other references Beentje, H.J., 1999; Wild, H., 1969.

Authors C.H. Bosch

OPHIOGLOSSUM RETICULATUM L.

Protologue Sp. pl. 2: 1063 (1753).

Family Ophioglossaceae

Chromosome number n = 240, 360, 480, 510, 435–570, 630

Synonyms *Ophioglossum vulgatum* L. var. *reticulatum* (L.) Luerss. (1875).

Vernacular names Adder's tongue fern (En). Langue de serpent, ophioglosse (Fr). Lingua de cobra (Po).

Origin and geographic distribution *Ophioglossum reticulatum* is a pantropical species that is widespread in tropical Africa: from Sierra Leone east to Ethiopia, and south to South Africa. It also occurs in Madagascar and other Indian Ocean islands.

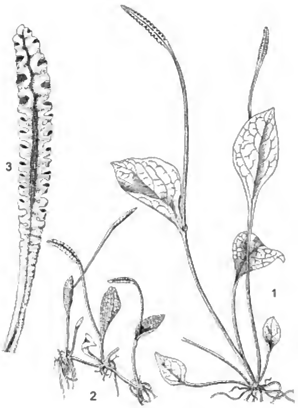
Uses The leaves of *Ophioglossum reticulatum* are eaten as a salad or cooked vegetable in Zanzibar (Tanzania). In Indonesia it is locally an appreciated vegetable, collected sedulously wherever it is common. The leaves should be blanched only; if boiled too much they turn into slime. In Madagascar the related *Ophioglossum ovatum* Bory is eaten boiled, and is especially sought by the Antandroy tribe.

A warm decoction of the rhizome of *Ophioglossum reticulatum* is used topically in Lesotho on boils. In Tanzania, the leaf juice is drunk against spasms of the heart. A report from Nigeria mentions two useful *Ophioglossum* species, called *Ophioglossum grande* and *Ophioglossum vulgatum*, but these species do not occur in West Africa. The first one possibly refers to *Ophioglossum reticulatum*, and it is stated that the young fronds are used as fodder for livestock (goats), and that the retted leaves are used as garden manure. Extracts of the rhizomes are used as antidote for snakebites. The second one possibly concerns the other most frequent *Ophioglossum* in the area, *Ophioglossum costatum* R.Br. A decoction of the rhizomes of these plants is taken internally to treat lung and heart diseases. The dried and pulverized rhizome is applied externally to sores, wounds and burns.

In the Philippines *Ophioglossum reticulatum* is used as an anti-inflammatory medicine; leaves boiled in oil are applied to wounds.

Properties Young leaves of *Ophioglossum* taste sweet. The presence of alkaloids, arbutin, amygdalin, saponin, formic acid and oxalic acid has been shown.

Botany Small erect fern 5–30 cm tall, with 1–2 leaves on a 1–2 cm long and about 2 mm thick rhizome with few fleshy roots. Leaves



Ophioglossum reticulatum – 1, plant habit; 2, plants connected by stolons; 3, fertile part of leaf.
Source: PROSEA

with up to 15 cm long petiole, blade cordate, rarely broadly elliptical or ovate, 3–7 cm × 3–8 cm, apex rounded with or without a small mucro, entire, with prominent anastomosing venation in a polygonal pattern. Fertile part of leaf spikelike, up to 25 cm long, arising from the base of the blade, bearing up to 45 pairs of sporangia in the upper quarter or less, apex acute; sporangia opening by a transverse slit. Spores subglobose, blackish, surface finely reticulate of two types, one alete with a diameter of 42–50 μm, the other trilete and 25–38 μm in diameter.

Ophioglossum reticulatum is quite uniform in Africa and can be satisfactorily characterized by the clearly cordate base of the blade in combination with the absence of a tuber. Worldwide, many varieties and subspecies have been described, causing much confusion. It seems best to regard them as one variable pantropical species.

The plants are only present above ground in the rainy season. They can form stolons and form rather extensive colonies.

Ecology *Ophioglossum reticulatum* grows in moist sandy soils, seasonally wet soils, along roads, on termite hills, in montane grassland among rocks and forest margins, from sea-level up to 2500 m altitude.

Management The plants are collected from the wild and traded locally. Commercial cultivation of *Ophioglossum reticulatum* is not practised, but for medicinal use it is often grown in pots. It can be propagated from spores and by rhizome cuttings. When grown from spores, plants can be harvested for their leaves after 1–2 years. When grown from rhizomes collected from the wild, harvesting may start after about 6 months. In agriculture it can become a weed, but does little harm because of its small size.

Genetic resources and breeding *Ophioglossum reticulatum* is found all over the tropics and is in no danger of genetic erosion. More research on the large variability seems appropriate.

Prospects *Ophioglossum reticulatum* has nutritional, medicinal and ornamental value, but it does not seem to be widely used in Africa. Because of the close resemblance of *Ophioglossum* species and their variability, it may very well be that other species are also consumed or used in similar ways. It seems worthwhile investigating the possibilities of cultivation and breeding.

Major references Burkill, H.M., 2000; Decary, R., 1946; Haerdi, F., 1964; Nwosu, M.O., 2002; Williams, R.O., 1949.

Other references Alston, A.H.G., 1959; Amoroso, V.B. & Ong, H.C., 2003; Burrows, J.E. & Johns, R.J., 2001; Khandelwal, S., 1990; Schelpe, E.A.C.L.E., 1970d; Tardieu-Blot, M.L., 1964d.

Sources of illustration Amoroso, V.B. & Ong, H.C., 2003.

Authors W.J. van der Burg

Based on PROSEA 15(2): Cryptogams: Ferns and fern allies.

ORTHANTHERA JASMINIFLORA (Decne.) Schinz

Protologue Verhandl. Bot. Ver. Brandenb. 30: 265 (1888).

Family Asclepiadaceae (APG: Apocynaceae)

Synonyms *Barrowia jasminiflora* Decne. (1844), *Orthanthera browniana* Schinz (1888).

Origin and geographic distribution *Orthanthera jasminiflora* occurs in DR Congo, Zambia, Angola, Namibia, Botswana and Zim-

babwe.

Uses In northern Botswana, the paired young fruits of *Orthanthera jasminiflora* are eaten fresh or cooked as a vegetable.

Botany Climbing herb up to 5 m long with a woody, stout rhizome; stem procumbent, branching, scabrous to pubescent. Leaves opposite, simple; petiole 2–10 mm long; blade linear, ovate or elliptical, 1.5–7 cm × 0.5–2.5 cm, base rounded, truncate or cordate, apex acute, margin entire but often wavy or crisped, rather thick and rigid, scabrous-pubescent. Inflorescence an umbel, 2–13-flowered; peduncle up to 4 cm long. Flowers bisexual, regular, 5-merous; pedicel 0.5–1.5 cm long; calyx divided with lanceolate lobes, up to 6 mm × 2 mm; corolla tubular, cream-coloured, strongly scented, pubescent, tube up to 2 cm long, globose-pentagonal at base, cylindrical above, lobes linear-lanceolate, up to 12 mm × 2 mm, spreading; corona lobes 1 mm long; stamens with connivent, linear anthers 1–2 mm long, apiculate; ovary superior, style shorter than anthers. Fruit a pair of follicles, each one fusiform, up to 10 cm × 12 mm, tapering into a long beak.

In Africa the genus *Orthanthera* comprises 5 species, but it is badly known.

Ecology *Orthanthera jasminiflora* grows in dry savanna.

Genetic resources and breeding It is unknown whether *Orthanthera jasminiflora* is in danger of genetic erosion.

Prospects The nutritional value of the fruits should be investigated before any prospect can be given.

Major references van Wyk, B.-E., van Oudtshoorn, B. & Gericke, N., 1997.

Other references Brown, N.E., 1902–1904.

Authors P.C.M. Jansen

OXYGONUM ALATUM Burch.

Protologue Trav. S. Africa 1: 548 (1822).

Family Polygonaceae

Synonyms *Oxygonum acetosella* Welw. (1869).

Vernacular names Salt of the tortoise (En).

Origin and geographic distribution *Oxygonum alatum* occurs in southern Africa, from Angola and Zambia south to South Africa.

Uses In the Kalahari Desert the whole young plant or the leaves are eaten raw, not only for the refreshing acid taste, but also for the moisture it contains.

Botany Annual herb, much branched from the crown of the root with erect, finely pubescent stems up to 30 cm tall; stem, ocrea and petiole often covered with cup-like scales. Leaves alternate, simple; ocrea funnel-shaped, greenish-white, membranous; petiole short; blade lanceolate to rhomboid, 2.5–3.5 cm long, base gradually narrowed, apex acute, margin entire to pinnatisect. Inflorescence a lax raceme 10–20 cm long. Flowers polygamous (bisexual or unisexual), in clusters of 2–3; perianth tubular, 5-lobed, lobes pinkish or white, 4 mm long; stamens 8; ovary included in the perianth tube, styles 3, filiform, connate at base, stigma capitate. Fruit an indehiscent, usually trigonous (sometimes rounded), ovoid nut, 8 mm long, enclosed by the perianth tube, with wings up to 6 mm broad, but sometimes the wings are absent; the faces of the fruit often have a small spreading prickle at about one-third distance from the base. Seed similar in shape to the nut.

Oxygonum comprises about 30 species and is confined to tropical Africa, South Africa and Madagascar.

Ecology *Oxygonum alatum* appears in the rainy season as an annual on deep sands.

Management *Oxygonum alatum* is not cultivated; it is only collected from the wild.

Genetic resources and breeding *Oxygonum alatum* is rather widespread and does not seem in danger of genetic erosion.

Prospects *Oxygonum alatum* will remain locally a useful vegetable, particularly in dry areas with poor sandy soils.

Major references Baker, J.G. & Wright, C.H., 1909–1913; Graham, R.A., 1957; van Wyk, B.E. & Gericke, N., 2000.

Authors P.C.M. Jansen

OXYGONUM ATRIPLICIFOLIUM (Meisn.) Martelli

Protologue Fl. bogos.: 69 (1886).

Family Polygonaceae

Synonyms *Ceratogonum atriplicifolium* Meisn. (1832), *Oxygonum somalense* Chiov. (1916), *Oxygonum fagopyroides* Peter (1932).

Origin and geographic distribution *Oxygonum atriplicifolium* occurs in eastern Africa from Egypt and Ethiopia to Mozambique, and in Madagascar.

Uses In Malawi the leaves of *Oxygonum atriplicifolium* are cooked with potashes, resulting in a slimy vegetable. In eastern Africa

macerated leaves are used as a dressing for abscesses and wounds and leaf juice is swallowed as a cure for cough.

Botany Slender, much branched, straggling and trailing herb with weak stems up to over 1 m long. Leaves alternate, simple; ocrea cylindrical, 1 cm long, pale brown, membranous, bearing a terminal fringe of long hairs; petiole 1–1.5 cm long; blade deltoid to lanceolate, 2–3 cm × 1.5–2 cm, base truncate to cuneate, apex very acute and sometimes aristate, margin entire or slightly uneven but not deeply lobed. Inflorescence a spike-like, slender raceme up to 30 cm long. Flowers bisexual or male, white or greenish, strongly heterostylous; pedicel filiform, longest in bisexual flowers; bisexual flowers with 6 linear to ovate tepals 1.5 mm long, inner 3 ones petaloid, styles 3, 2 mm long and connate in lower part; male flowers with 5 narrowly oblong tepals. Fruit a fusiform nut 5–7 mm long, pendulous, glabrous or pubescent, bearing 3 spreading prickles 1 mm long at the centre or slightly below.

Oxygonum comprises about 30 species and is confined to tropical Africa, South Africa and Madagascar.

Ecology *Oxygonum atriplicifolium* grows under hedges, in cultivated and waste places, from sea-level up to 2000 m altitude.

Management *Oxygonum atriplicifolium* is collected from the wild and is not cultivated.

Genetic resources and breeding *Oxygonum atriplicifolium* is widespread and not in danger of genetic erosion.

Prospects *Oxygonum atriplicifolium* will remain a minor vegetable and medicinal plant, only locally of some importance.

Major references Graham, R.A., 1957; Graham, R.A., 1958; Watt, J.M. & Breyer-Brandwijk, M.G., 1962; Williamson, J., 1955.

Other references Hedberg, O., 2000; Jansen, P.C.M., 1981; Kokwaro, J.O., 1993; Thulin, M., 1993b.

Authors P.C.M. Jansen

OXYGONUM SALICIFOLIUM Dammer

Protologue Engl., Pflanzenw. Ost-Afrikas, C: 171 (1895).

Family Polygonaceae

Vernacular names Bamba, kindiri (Sw)

Origin and geographic distribution *Oxygonum salicifolium* is only found in Kenya and Tanzania.

Uses In the coastal area of Kenya the leaves of *Oxygonum salicifolium* are used as a cooked vegetable, often mixed with *Amaranthus* or other vegetable species to improve the taste.

Botany Creeping herb with ascending or prostrate woody branches bearing pubescent shoots up to 35 cm long. Leaves alternate, simple, sessile; ocrea cylindrical, up to 1 cm long, bearing at apex red hairs up to 9 mm long; blade linear-lanceolate, 3–7 cm × 2–10 mm, base narrowed, apex acute and often mucronate, margin not or slightly sinuous, midrib prominent below. Inflorescence a spike-like raceme, slender, 12–20 cm long. Flowers bisexual and male; bisexual flowers tubular with perianth tube accrescent around ovary and with perianth lobes withering; male flowers with a very short perianth tube and 4–5 petaloid tepals 4–6 mm long; stamens 8 in 2 series, 5 outer adnate to the tepals near their bases, 3 inner with a flattened basis forming a ring around the base of the style, filaments 4 mm long; styles 3, free or adnate at base, stigmas capitate. Fruit a pubescent nut c. 1 cm long, bearing subcentrally 3 prickles each 3–4 mm long.

Oxygonum comprises about 30 species and is confined to tropical Africa, South Africa and Madagascar.

Ecology *Oxygonum salicifolium* grows in grassland and disturbed ground, from sea-level up to 1600 m altitude.

Management *Oxygonum salicifolium* is only collected from the wild and is not cultivated.

Genetic resources and breeding Although *Oxygonum salicifolium* is not widespread, it is common in disturbed habitats and not in danger of genetic erosion.

Prospects *Oxygonum salicifolium* will only remain of minor and local importance as a vegetable.

Major references Graham, R.A., 1957; Maundu, P.M., Ngugi, G.W. & Kabuye, C.H.S., 1999.

Other references Graham, R.A., 1958.

Authors P.C.M. Jansen

OXYGONUM SINUATUM (Meisn.) Dammer

Protologue Engl., Pflanzenw. Ost-Afrikas, C: 170 (1895).

Family Polygonaceae

Chromosome number $2n = 52$

Synonyms *Ceratogonum cordofanum* Meisn. (1856), *Ceratogonum sinuatum* Meisn. (1856), *Oxygonum atriplicifolium* (Meisn.) Martelli var. *sinuatum* (Meisn.) Baker (1909).

Vernacular names Kindri, bamba (Sw).

Origin and geographic distribution *Oxygonum sinuatum* is widely distributed in eastern and southern Africa, from Sudan southwards to Angola and South Africa.

Uses In Ethiopia, Uganda and Kenya the leaves of *Oxygonum sinuatum* are eaten raw or boiled as a vegetable. In Uganda the popularity of *Oxygonum sinuatum* as a leafy vegetable differs per region; it is considered a famine food in some regions, and a favourite dish in others. Medicinally the leaves are applied to boils, and stems are chewed to treat tonsillitis. The leaf juice is used for treating fungal infections of legs and feet and to treat eye infections.

Properties The raw leaves of *Oxygonum sinuatum* have an acid taste; in powdered form the taste is mild.

Botany Spreading, decumbent or erect annual herb with green to red-brown, glabrous to pubescent stems, up to 1 m tall. Leaves alternate, simple; ocrea cylindrical, up to 8 mm long, reddish, usually fringed with long hairs at apex; petiole 0.5–3 cm long; blade ovate to elliptical in outline, 4–8 cm × 1–3 cm, usually slightly to deeply incised with rounded or acute lobes. Inflorescence a spike-like raceme up to 45 cm long. Flowers bisexual and male, white or pink, slightly heterostylous; pedicel stumpy in bisexual flowers, filiform in male flowers; perianth tube 1–1.5 mm long, tepals ovate-elliptical, up to 3 mm long. Fruit a fusiform nut 5–6.5 mm long, bearing subcentrally 3 spreading prickles up to 2 mm long.
Oxygonum comprises about 30 species and is confined to tropical Africa, South Africa and Madagascar.

Ecology *Oxygonum sinuatum* is a common weed in fields and on waste ground, from sea-level up to 2400 m altitude. In Uganda it occurs on well-drained loamy soils in areas with an annual rainfall of 1000–1600 mm.

Management *Oxygonum sinuatum* is mostly collected from the wild, but in Uganda it is protected in home gardens. Dried and powdered leaves and shoots are stored for future use.

Genetic resources and breeding *Oxygonum sinuatum* is widespread and not in danger of genetic erosion.

Prospects Locally *Oxygonum sinuatum* will remain a useful vegetable and medicinal plant.

Major references Graham, R.A., 1957; Graham, R.A., 1958; Katende, A.B., Ssegawa, P. & Birnie, A., 1999; Maundu, P.M., Ngugi, G.W. & Kabuye, C.H.S., 1999; Westphal, E., 1975.

Other references Baker, J.G. & Wright, C.H., 1909–1913; Hedberg, O., 2000; Robyns, W., 1948b.

Authors P.C.M. Jansen

PASTINACA SATIVA L.

Protologue Sp. pl. 1: 262 (1753).

Family Apiaceae (Umbelliferae)

Chromosome number $2n = 22$

Vernacular names Parsnip (En). Panais (Fr). Pastinaga (Po).

Origin and geographic distribution Parsnip is native to Europe and temperate Asia. It is cultivated mainly in temperate regions worldwide and only occasionally in cooler parts of the tropics, including East and southern Africa. It is mainly grown in home gardens and for specialty markets. It was already a popular crop during Roman times and one can still find a wide diversity in Moroccan and Algerian markets.

Uses The fleshy, aromatic and slightly mucilaginous root is eaten as a cooked or fried vegetable. It is also used in soups and to add flavour to stews. It is especially popular in the United Kingdom. The seed, which tastes similar to dill, is occasionally used as a condiment. The leaves have diuretic properties. A poultice from the roots has been applied to sores and inflammations, and to treat skin diseases.

Properties The nutritional composition of parsnip root per 100 g edible portion is: water 79.5 g, energy 3140 kJ (750 kcal), protein 1.2 g, fat 0.3 g, carbohydrate 18.0 g, fibre 4.9 g, Ca 362 mg, P 71 mg, Fe 0.6 mg, Mg 29 mg, Zn 0.6 mg, vitamin A absent, thiamin 0.09 mg, riboflavin 0.05 mg, niacin 0.70 mg, folate 67 µg, ascorbic acid 17.0 mg (USDA, 2002).
All parts of parsnip contain essential oil. The essential oil from the fully-grown root is rich in myristicin and terpinolene and contains small amounts of (E)-β-farnesene, β-bisabolene, β-sesquiphellandrene and γ-palmitolactone. Furanocoumarins are present in the plant; these compounds may cause contact dermatitis. Parsnip contains minute amounts of the steroid 5α-androst-16-en-3-one or boar-pheromone which contributes to its characteristic fragrance.

Botany Glabrous to slightly hairy biennial herb up to 150 cm tall, with fusiform, fleshy white taproot; stem erect, hollow, grooved. Leaves alternate, pinnate, without stipules; petiole sheathed at base; leaflets sessile, ovate-

oblong, often with some lobes at base, 2–13 cm × 1–5 cm, toothed. Inflorescence a terminal, compound umbel with unequal rays; involucral bracts 0–2, deciduous. Flowers bisexual, but male flowers present in addition to bisexual flowers, c. 2 mm in diameter, 5-merous; petals yellow; ovary inferior, 2-celled. Fruit a flattened ellipsoid schizocarp 5–7 mm long, ribbed, slightly winged. Seedling with epigeal germination: hypocotyl 0.5–1.5 cm long, epicotyl absent; cotyledons stalked, ovate-lanceolate, herbaceous.

Parsnip is a slow-growing, deep-rooted plant. The flowers are pollinated by insects. Parsnip is self-fertile.

Ecology Parsnip is a cool season crop. Optimum temperature for growth is 15–18°C. Roots produced under warm conditions do not have the strong and distinctive flavour of those grown under cooler conditions. Parsnip is biennial and requires vernalization for flower induction. It can grow in slightly shady localities (open woodland) or in full sunlight. In the tropics it can only be cultivated above 900 m altitude. The root is tolerant of hard frost. Under the influence of low temperatures starch in the root is converted to sugars. Parsnip requires a deep, light to medium-textured soil with good drainage. In clay soils germination and root growth are poor.

Management Parsnip seed is sown in situ, thinly in rows 40–50 cm apart at a spacing of 1–2 cm in the row and covered with about 1 cm of fine soil. The weight of 1000 seeds is about 3.5 g. Seed is difficult to preserve and often has a low germination rate. Germination is best at 19–24°C, but still takes about 2 weeks. In a soil that has a capping tendency, a light irrigation just prior to germination helps seedlings to emerge. In home gardens parsnip seed is sometimes mixed with radish seed. The quick growing radish breaks the soil crust and can be harvested before it starts competing with the parsnip plants. Plants are thinned after 4–5 weeks to a spacing of 10–12 cm. Slight earthing-up after thinning is recommended. Parsnip needs careful weeding as early growth is slow. The application of a compound fertilizer (8–14–10) at a rate of 500–700 kg/ha at planting is recommended, if necessary top-dressed with 20 kg N after 4–6 weeks. Fresh manure should be avoided as it causes plants to become hairy and branched. Parsnip prefers a constantly moist soil. Erratic irrigation may cause roots to crack or become fibrous. Parsnip does not suffer much from pests or diseases. To avoid white mould (*Sclerotinia* sp.) and root-knot nematodes parsnip should be grown in a wide crop rotation. *Alternaria* leaf blight, powdery mildew (*Erisiphe umbelliferarum*) and *Cercospora* leaf blight may occur and may need control by fungicides. Leaf blight and powdery mildew are favoured by warm humid weather; improved aeration may reduce their incidence. Cutworms may cause some damage.

Parsnip roots are ready for harvesting after 90–150 days. In temperate areas they are often left until after the first frost as their sweetness increases under low temperatures. They can not be pulled up and have to be uprooted by careful digging. A yield of 25 t/ha is considered good. Once parsnip roots have been harvested they lose water quickly. They can be stored in soil clamps or under refrigeration at 0°C and relative humidity of at least 90%.

Genetic resources and breeding The old cultivar 'Hollow Crown' is mostly cultivated in East Africa; other well-known cultivars are 'Guernsey' and 'Offenham', both with shorter roots. No breeding programmes are known to exist. The North Central Regional PI Station, Ames, Iowa, United States maintains a small collection of *Pastinaca* germplasm.

Prospects In tropical Africa parsnip is likely to remain a vegetable of minor importance, mainly for consumers of European origin.

Major references Hadfield, J., 1960; Lawrence, B.M., 2002; Rubatzky, V.E. & Yamaguchi, M., 1997; USDA, 2002a; Wells, P.O., 1979.

Other references Foster, S. & Duke, J.A., 1999; Foster, R., Egel, D. & Maynard, E., 2003; Fritz, D., Stolz, W., Venter, F., Weichmann, J. & Wonneberger, C., 1989.

Authors L.P.A. Oyen

PEDALIUM MUREX L.

Protologue Syst. nat. ed. 10 : 1123 (1759).

Family Pedaliaceae

Chromosome number $2n = 16$

Origin and geographic distribution *Pedalium murex* is widespread in West, East and southern tropical Africa, Madagascar, and tropical Asia (from India and Sri Lanka to Indonesia).

Uses In tropical Africa and India the leaves of *Pedalium murex* are collected from the wild and eaten boiled as a vegetable. In Tanzania the water in which the leaves have been boiled or a decoction of the root is drunk to treat ve-

nereal diseases. The viscid mucilage produced by the plant is used as a demulcent, diuretic and tonic, to treat gonorrhoea and dysuria, and to dissolve urethral stones. In India the plant is taken as an emmenagogue and ecbolic and the root is considered antibilious. The hard and prickly fruits are sold as medicine on Indian markets.

Properties There is no information on the chemical composition of *Pedalium murex* leaves. Alkaloids, a greenish fatty oil, a little resin, phenolic acids, vanillin and flavones have been isolated from the fruits. The leaves and roots have been used in a clinical test with patients suffering from gonorrhoea; it was found to have no effect. Possibly because of its foetid smell, *Pedalium murex* is not grazed by livestock in Somalia.

Botany Erect or ascending annual herb up to 75 cm tall, slightly succulent, with much-branching stem. Leaves opposite or alternate, simple; stipules absent; petiole up to 3.5 cm long; blade oblong-elliptical to obovate, up to 5 cm × 3.5 cm, base acute, apex rounded or truncate, margin irregularly toothed or lobed but sometimes entire, glabrous above, scaly-glandular below. Flowers solitary in leaf axils, bisexual, almost regular, 5-merous; pedicel slender, short, at base bearing nectarial glands; calyx deeply divided into lanceolate segments c. 2 mm long, persistent in fruit; corolla narrowly funnel-shaped, yellow, with tube up to 2.5 cm long and spreading, almost equal lobes c. 5 mm long, glabrescent or with a few hairs in the throat; stamens 4, included in corolla tube, filaments glandular hairy at base; ovary superior, 2-celled, style slender, stigma 2-lobed. Fruit an indehiscent capsule 1–2 cm × 0.5–1 cm, hard, pyramidal, 4-angled, with a spreading spine c. 3 mm long at the base of each of the 4 angles, abruptly contracted below the spines, rounded to acute at apex, rugose or tuberculate, few-seeded. Seeds narrowly cylindrical, c. 6 mm × 1.5 mm, 3-angled towards the apex, black.

Pedalium comprises only a single species. Plants of *Pedalium murex* with prostrate stems can cover an area up to 1 m in diameter. The flowers open in the morning and close early to late in the afternoon. Plants can be found flowering throughout the year.

Ecology *Pedalium murex* is often found at the edge of beaches or in open grassland not too far from the seashore, up to 500 m altitude. It is a saline soil indicator, and occurs on sandy and limestone soils.

Genetic resources and breeding *Pedalium murex* is widespread and not in danger of genetic erosion.

Prospects *Pedalium murex* will remain a minor leaf vegetable of only local importance. Its nutritional and medicinal properties need further research.

Major references Bhakuni, R.S., Shukla, Y.N. & Thakur, R.S., 1992; Burkill, H.M., 1997; Ihlenfeldt, H.-D., 1988.

Other references Bruce, E.A., 1953; Heine, H., 1963b; Humbert, H., 1971; Kokwaro, J.O., 1993; Theobald, W.L. & Grupe, D.A., 1981; Watt, J.M. & Breyer-Brandwijk, M.G., 1962.

Authors P.C.M. Jansen

PENTANISIA SCHWEINFURTHII Hiern

Protologue Oliv., Flora trop. Afr. 3: 131 (1877).

Family Rubiaceae

Chromosome number $2n = 40$

Synonyms *Pentanisia crassifolia* K.Krause (1907), *Pentanisia variabilis* auct. non Harv.

Vernacular names Rhodesian forget-me-not (En). Mlangaze (Sw).

Origin and geographic distribution *Pentanisia schweinfurthii* is widespread in tropical Africa, from Nigeria and Sudan south to Angola and Mozambique.

Uses Crushed leaves and tips of flowering shoots of *Pentanisia schweinfurthii* are locally eaten as a cooked vegetable, particularly in the dry season, e.g. in Tanzania, Malawi and Zambia. In Malawi the ash of the burned plant is used as salt. A decoction of leaves and roots is taken in eastern Africa to stop diarrhoea.

Botany Perennial herb up to 25 cm tall, with several stems arising from a woody rootstock, glabrous to hairy. Leaves opposite, simple; stipules with 2–4 deltoid lobes; petiole up to 2 mm long; blade very variable, round to elliptical-obovate or linear, 0.3–5.5 cm × 0.2–2 cm, base cuneate, apex acute to obtuse, usually glabrous. Inflorescence head-like and up to 2.5 cm long, or branched and spike-like and 2–3.5 cm long; peduncle up to 7 cm long. Flowers bisexual, regular, usually 5-merous; calyx tubular, tube squarish, 1.5 mm long, longest lobe up to 3.5 mm × 1 mm, other lobes much smaller; corolla tubular, bright blue, white, pale lilac or purple, tube up to 13 mm long, densely hairy at the throat, lobes ovate-oblong-lanceolate, 2–6 mm × 1–2 mm; ovary 2-celled, style filiform, exserted 2–4 mm in long-styled

flowers, stigma divided into 2 filiform lobes up to 2 mm long. Fruit capsule-like, ovoid, 1.5–2.5 mm × 1.5–2 mm, thin-walled, indehiscent, usually 2-seeded. Seeds broadly elliptical in outline, concave-convex, 2 mm × 1.5 mm × 0.5 mm, yellow brown, finely marked with brown.
Pentanisia is confined to tropical Africa (including Madagascar) and comprises 15 species.

Ecology *Pentanisia schweinfurthii* occurs in grasslands and woodlands, always in areas subject to burning; it is fire-resistant. In eastern Africa it grows at altitudes of 800–2250 m. It is also a common weed of cultivation.

Management *Pentanisia schweinfurthii* is collected from the wild and is not cultivated.

Genetic resources and breeding *Pentanisia schweinfurthii* is widespread and not in danger of genetic erosion.

Prospects *Pentanisia schweinfurthii* will remain a minor vegetable, most important in the dry season when other vegetables are scarce. Its nutritional and medicinal value deserve more research.

Major references Burkill, H.M., 1997; Verdcourt, B., 1952; Verdcourt, B., 1976; Williamson, J., 1955.

Other references Kokwaro, J.O., 1993; Malaisse, F., Grégoire, J., Nyembo, L. & Robbrecht, E., 1979; Puff, C. & Robbrecht, E., 1989; Verdcourt, B., 1989.

Authors P.C.M. Jansen

PENTARRHINUM INSIPIDUM E.Mey.

Protologue Comm. pl. Afr. austr.: 220 (1837).

Family Asclepiadaceae (APG: Apocynaceae)

Chromosome number $2n = 22$

Vernacular names African heartvine (En).

Origin and geographic distribution *Pentarrhinum insipidum* is widespread in Namibia, Zimbabwe and South Africa and again in the northern Tanzania-Kenya area, from where it extends into Ethiopia; it is known from one area in Sudan. Between those regions it is rare and has, for example, not yet been collected in northern Zambia or northern Malawi.

Uses In southern Africa young leaves and fruits are used as raw or cooked vegetables. Sometimes the leaves are pounded with leaves of other species or with the tubers of several small *Asclepiadaceae*. The young fruits may be stored for 3 weeks before they deteriorate; older fruits (when the seeds inside have turned brown) become too hard to make good eating. They exude a copious amount of harmless latex and have a nutty, slightly peppery flavour.
In Tanzania a decoction of the leaves is used to wash boils, and after washing the boils are covered with hot leaves. In Malawi the roots are said to be used as medicine. The leaves might be a good fodder for domestic stock.

Properties *Pentarrhinum insipidum* is certainly not poisonous, although it has been reported occasionally as being so. Fresh leaves contain per 100 g: water 85 g, energy 192 kJ (46 kcal), protein 3.5 g, fat 0.5 g, carbohydrate 6.7 g, fibre 2 g, Ca 370 mg, P 63 mg, Fe 9 mg, thiamin 0.2 mg, riboflavin 0.3 mg, niacin 1 mg, ascorbic acid 16 mg. Fresh young fruits contain per 100 g: water 88 g, energy 157 kJ (37 kcal), protein 2.3 g, fat 0.2 g, carbohydrate 6.6 g, fibre 1.5 g, Ca 72 mg, P 47 mg, Fe 0.8 mg (Arnold, T.H., Wells, M.J. & Wehmeyer, A.S., 1985).

Botany Perennial, climbing, latex-containing herb, with elongated tuberous roots and strongly branched, annual shoots 2–3 m long, glabrous to sparsely pubescent. Leaves opposite, simple; petiole 2–5 cm long; blade ovate, 2.5–6.5 cm × 2–5 cm, base cuneate to cordate, apex acuminate, margin entire. Inflorescence cymose, 5–15-flowered; peduncle 3–4 cm long. Flowers bisexual, regular, 5-merous, with aromatic scent; pedicel 0.5–2 cm long; calyx rotate, lobes triangular, up to 2.5 mm long, connate at base, pubescent outside; corolla with ovate to oblong lobes up to 6 mm × 3.5 mm, connate at base, fully reflexed at anthesis, margin ciliate, green-yellowish; corona c. 3 mm long, fleshy, at apex with horn-like ornaments; anthers with connective appendages and wings; ovary superior, style apex flat. Fruit a pair of follicles, but usually only one developed, ellipsoid, 5–9 cm × 1.5–2 cm, pale brown, smooth to densely covered with 2–4 mm long protuberances. Seeds ovoid, about 6 mm × 2 mm, brown, margin winged, apex with a coma of 3–4 mm long hairs.
Pentarrhinum comprises only 2 species. The other species is *Pentarrhinum abyssinicum* Decne., which is more widely distributed but more scattered than *Pentarrhinum insipidum*, occurring from Cameroon to Namibia and from Ethiopia to Zimbabwe. In the literature, the name *Pentarrhinum insipidum* has sometimes erroneously been used for *Pentarrhinum abyssinicum*.

Ecology *Pentarrhinum insipidum* is associated with shrubland and savanna, in dry or well-drained conditions, but does not tolerate extremes of dry and wet. It ranges from sea-

level up to 2200 m altitude, but is most common between 600–1600 m.

Management *Pentarrhinum insipidum* can easily be grown from seed and is a rapid producer of green material.

Genetic resources and breeding *Pentarrhinum insipidum* is widespread in East and southern Africa and not in danger of genetic erosion.

Prospects In southern Africa *Pentarrhinum insipidum* is an important vegetable from the wild. It is considered to have some potential for development as a commercial vegetable. Its medicinal value needs confirmation.

Major references Arnold, T.H., Wells, M.J. & Wehmeyer, A.S., 1985; Liede, S. & Nicholas, A., 1992; Story, R., 1958.

Other references Burkill, H.M., 1985; van Wyk, B.-E., van Oudtshoorn, B. & Gericke, N., 1997; Watt, J.M. & Breyer-Brandwijk, M.G., 1962; Williamson, J., 1955.

Authors P.C.M. Jansen

PENTODON PENTANDRUS (Schumach. & Thonn.) Vatke

Protologue Öst. Bot. Zeitschr. 25: 231 (1875).

Family Rubiaceae

Synonyms *Hedyotis pentandra* Schumach. & Thonn. (1827), *Oldenlandia macrophylla* DC. (1830), *Oldenlandia pentandra* (Schumach. & Thonn.) DC. (1830).

Origin and geographic distribution *Pentodon pentandrus* is widespread all over tropical Africa and has been introduced in the southern United States, Cuba, Nicaragua and Brazil. In the United States it has become a weed known as Hale's pentodon.

Uses The leaves and young shoots of *Pentodon pentandrus* are reportedly eaten as a vegetable in Ghana and Kenya. The plant is grazed by domestic stock. A decoction of the plant is used internally and externally to promote lactation of nursing mothers. In Sierra Leone ground-up leaves mixed with oil are rubbed onto the body against fever, in Ghana against rheumatism and in Nigeria against headache. Leaf sap is instilled in the eyes to cure conjunctivitis. In East Africa an infusion of the roots is drunk to alleviate the pain of a swollen spleen.

Botany Annual or short-lived perennial herb with slender rootstock and decumbent to erect stem up to 90 cm long. Leaves opposite, simple, sessile; stipules with short sheath, fringed; blade elliptical to linear-lanceolate, 1.5–8 cm × 0.5–2.5 cm. Inflorescence apparently axillary and verticillate with widely spaced nodes each bearing 1–4 flowers, up to 9 cm long; peduncle up to 6.5 cm long. Flowers bisexual, small, regular, 5-merous, heterostylous; pedicel up to 1.5 cm long, spreading; calyx tubular with triangular lobes c. 1 mm long; corolla tubular with hairy throat and ovate-triangular lobes 1–3 mm long, white, pink, blue or mauve; stamens inserted at throat or base of corolla tube; ovary inferior, 2-celled, style slender, c. 1 mm or 2–3.5 mm long, stigma 2-lobed. Fruit a capsule 2–4 mm long, crowned by the persistent calyx lobes, many-seeded. Seeds angular, small, black.

Ecology *Pentodon pentandrus* grows in swamps, lake and river shores and on seasonally wet grounds, from sea-level up to 2250 m altitude.

Management *Pentodon pentandrus* is only collected from the wild and is not cultivated.

Genetic resources and breeding *Pentodon pentandrus* is widespread and not in danger of genetic erosion.

Prospects *Pentodon pentandrus* will remain a minor vegetable, always nearby in wetter locations. Its nutritional and medicinal value merit research.

Major references Burkill, H.M., 1997; Kokwaro, J.O., 1993; Verdcourt, B., 1976.

Other references Verdcourt, B., 1989.

Authors P.C.M. Jansen

PERSICARIA ATTENUATA (R.Br.) Soják

Protologue Preslia 46: 152 (1974).

Family Polygonaceae

Synonyms *Polygonum tomentosum* Willd. (1799) non Schrank, *Polygonum attenuatum* R.Br. (1810), *Polygonum pulchrum* Blume (1826).

Vernacular names Watersmart weed, hairy knotweed (En).

Origin and geographic distribution *Persicaria attenuata* is widespread in the tropics and subtropics of Africa, Asia and Australia. In Africa it is common in wet localities.

Uses The leaves of *Persicaria attenuata* are locally (e.g. in Benin and Tanzania) used as a fresh salad or as a cooked vegetable and are also grazed by stock. In South-East Asia the leaves are eaten with food as a tonic and to purify the blood. *Persicaria attenuata* is widely

used medicinally. In East Africa the leaves are used in treatments for syphilis, rheumatism and swellings. In southern Africa a decoction of creeping stems is applied to cattle suffering from black gall sickness. In DR Congo the plant is burnt to obtain a vegetable salt which is rich in potassium and is applied to sores on the back and chest of scrofulous hunchbacked children.

Properties The nutritive value of *Persicaria attenuata* is not known; it may be similar to that of *Persicaria decipiens* (R.Br.) K.L.Wilson, which is also used as a vegetable in Africa. The rhizome contains 2.5% of an acrid resin which is a depressant and can arrest the heart.

Botany Robust, hairy, rhizomatous perennial herb up to 2 m tall, with branched stems, basally creeping and rooting at the nodes, becoming hollow when older. Leaves alternate, simple; ocrea cylindrical, up to 4 cm long, surface coarsely villous, apex with a fringe of bristles; petiole up to 7 mm long; blade narrowly elliptical to narrowly ovate, 5–25 cm × 1–6 cm, pubescent, veins prominent below. Inflorescence a panicle of 2–5 spike-like racemes 5–8 cm long, usually leafless; peduncle stout, often in pairs; bracts ovate, 2–3 mm long, reddish, fringed terminally. Flowers bisexual, distinctly heterostylous; pedicel exceeding the bracts by 1–2 mm; perianth campanulate, 3–4.5 mm long, white or pink, lobes 4–5, oblong-elliptical, 2–3 mm long; stamens 5–8; ovary superior, 1-celled, styles 2, united at base, stigmas capitate. Fruit a lens-shaped nut, sometimes flattened on one side, 2–3 mm long, shiny black.

The taxonomy of *Persicaria* has not yet stabilized, at present comprising about 150 species. Most species have been described in the genus *Polygonum*, from which *Persicaria* is a segregate.

Persicaria attenuata is very variable and 3 subspecies have been distinguished, mainly based on hairiness of ocrea and leaf, and leaf and fruit form. Of these, subsp. *africana* K.L.Wilson is the only one in Africa. Subsp. *attenuata* occurs in South-East Asia and Australia and subsp. *pulchra* (Blume) K.L.Wilson in eastern Asia.

Ecology *Persicaria attenuata* grows in and beside water, often forming large patches with long floating stems that root at the lowest nodes, from sea-level up to 1000 m altitude. In Sierra Leone *Persicaria attenuata* is sometimes a troublesome weed in rice, although it is also considered an indicator of land suitable for rice cultivation.

Management *Persicaria attenuata* is collected from the wild and is not cultivated.

Genetic resources and breeding *Persicaria attenuata* is very widespread and not in danger of genetic erosion.

Prospects *Persicaria attenuata* will remain a locally used vegetable and medicinal plant. More research is needed to verify its nutritional and medicinal value.

Major references Burkill, H.M., 1997; Decary, R., 1946; Kokwaro, J.O., 1993; Ruffo, C.K., Birnie, A. & Tengnäs, B., 2002; Wilson, K.L., 1990.

Other references Busson, F., 1965; Cavaco, A., 1953; Graham, R.A., 1958; Hedberg, O., 2000; Keay, R.W.J., 1954e; Nguyen Thi Do, 2001a; Thulin, M., 1993b; van den Bergh, M.H., 1993; van der Zon, A.P.M. & Grubben, G.J.H., 1976; Watt, J.M. & Breyer-Brandwijk, M.G., 1962.

Authors P.C.M. Jansen

PERSICARIA DECIPIENS (R.Br.) K.L.Wilson

Protologue Telopea 3: 178 (1988).

Family Polygonaceae

Synonyms *Polygonum salicifolium* Brouss. ex Willd. (1809), *Polygonum decipiens* R.Br. (1810), *Polygonum serrulatum* Lag. (1816), *Persicaria salicifolia* (Brouss. ex Willd.) Assenov (1966) non S.F.Gray.

Vernacular names Willow weed, slender knotweed, snake root (En). Renouée à feuilles de saule (Fr).

Origin and geographic distribution *Persicaria decipiens* is widespread from the Mediterranean region to southern Africa, also in South-East Asia and Australia. It has become widely naturalized elsewhere (e.g. in Madagascar).

Uses In Africa and elsewhere, the leaves of *Persicaria decipiens* are locally eaten as a cooked vegetable, but usually considered a famine food. In DR Congo the plant is burnt to obtain vegetable salt. In Tanzania the leaves are used medicinally as a purgative, in Guinea they are applied to syphilitic sores; in southern Africa a leaf paste is applied to sores.

Properties Leaves of *Persicaria decipiens* contain per 100 g: water 80.0 g, energy 268 kJ (64 kcal), protein 3.6 g, fat 0.3 g, carbohydrate 14.7 g, fibre 3.5 g, Ca 150 mg, P 46 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). Cooked leaves are slimy, coarse and not very popular.

Botany Erect or basally decumbent, slender

annual herb up to 1 m tall, with simple or branched, glabrous stem, rooting at lower nodes. Leaves alternate, simple, subsessile; ocrea cylindrical, up to 2 cm long, thinly covered with bristly hairs and terminally fringed with stiff bristles up to 2.5 cm long; blade lanceolate-elliptical, 8–15 cm × 1–2 cm, base attenuate, apex acute, margins ciliate. Inflorescence a slender, spike-like raceme 2–9 cm long, often 2–7 together to appear somewhat digitate and zigzag when young; bracts red-brown, with a terminal fringe of rigid bristles. Flowers bisexual, heterostylous; perianth 2–3 mm long, 5-lobed with broadly ovate lobes, pink or white; stamens 7–8; ovary superior, 1-celled, styles 3, united in lower half, stigmas orange. Fruit a trigonous or lens-shaped nut up to 2.5 mm long, shiny black.

The taxonomy of *Persicaria* has not yet stabilized, at present comprising about 150 species. Most species have been described in the genus *Polygonum*, from which *Persicaria* is a segregate.

Ecology *Persicaria decipiens* grows in damp localities, often in water, from sea-level up to 2400 m altitude. Locally it may be troublesome because of its invasive nature.

Management *Persicaria decipiens* is only collected from the wild and not cultivated.

Genetic resources and breeding *Persicaria decipiens* is widespread and not in danger of genetic erosion.

Prospects *Persicaria decipiens* will remain locally a famine food always available from the wild. Its medicinal properties need more research.

Major references Burkill, H.M., 1997; Katende, A.B., Ssegawa, P. & Birnie, A., 1999; Kokwaro, J.O., 1993; Ruffo, C.K., Birnie, A. & Tengnäs, B., 2002; Tredgold, M.H., 1986.

Other references Cavaco, A., 1953; Graham, R.A., 1958; Hedberg, O., 2000; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Nguyen Thi Do, 2001a; Petit, E., 1958; Thulin, M., 1993b; van den Bergh, M.H., 1993; Williamson, J., 1955; Wilson, K.L., 1990.

Authors P.C.M. Jansen

PERSICARIA SENEGALENSIS (Meisn.) Soják

Protologue Preslia 46: 155 (1974).

Family Polygonaceae

Synonyms *Polygonum senegalense* Meisn. (1826).

Vernacular names Silver snake root (En).

Origin and geographic distribution *Persicaria senegalensis* is widespread in tropical and subtropical Africa, including South Africa and Madagascar.

Uses The tender leaves of *Persicaria senegalensis* are eaten cooked as a vegetable. Only in times of drought it is grazed by livestock. In Kenya and DR Congo the plant is burnt to make a vegetable salt. In Senegal a leaf decoction is taken in draught and by enema to treat syphilis in a mixture with other plants. In Nigeria and Ethiopia pounded leaves are applied to swellings, syphylitic sores or skin affections; in Tanzania pounded roots are used in the same way. The plant is also used as a veterinary medicine in Madagascar and elsewhere. In Tanzania a black dye is prepared from the roots. *Persicaria senegalensis* has potential as an aquatic ornamental.

Properties A chemical analysis of leaves of *Persicaria senegalensis* is not available, but the nutritive value may be similar to that of *Persicaria decipiens* (R.Br.) K.L.Wilson. The roots are said to be toxic. An abundance of saponins is present in the leaves. A crude water extract of the plant killed the freshwater snails *Lymnae natalensis* and *Biomphalaria pfeifferi*.

Botany Erect perennial herb up to 3 m tall, glabrous to white-tomentose, with brown, striate stem inflated just above the nodes and rooting at lower nodes. Leaves alternate, simple; ocrea cylindrical, up to 4 cm long, membranous, glabrous, not fringed; petiole 1–7 cm long; blade lanceolate, up to 30 cm × 8 cm, tapering at both ends, lower surface with numerous small glands and often strigose on the midrib and along the edges. Inflorescence a panicle of 1–several spike-like racemes up to 10 cm long; peduncle with orange glands; bracts ovate-truncate, 3 mm long, usually with fringed margin. Flowers bisexual; perianth campanulate with 4–5 lobes c. 3 mm long, pink, greenish or white, gland-dotted; stamens 4–5; ovary superior, 1-celled, styles 2. Fruit a lens-shaped nut 2.5–3.5 mm long, shiny black.

The taxonomy of *Persicaria* has not yet stabilized, at present comprising about 150 species. Most species have been described in the genus *Polygonum*, from which *Persicaria* is a segregate.

Persicaria senegalensis is variable in its indumentum, from glabrous to densely white woolly tomentose. This has resulted in the distinction of several subspecies, varieties and forms, but numerous intermediate types exist, sometimes even on the same plant. *Persicaria senegalensis*

much resembles *Persicaria glabra* (Willd.) M.Gómez, but it is usually larger, leaves are wider and have a strigose midrib, its perianth is longer and its fruit never triangular. In Madagascar the leaves of *Persicaria glabra* are also used as a vegetable.

Ecology *Persicaria senegalensis* grows in damp localities, along lake shores and streams, and in swamps, at 400–3000 m altitude.

Management *Persicaria senegalensis* is not cultivated and only collected from the wild.

Genetic resources and breeding *Persicaria senegalensis* is widespread and not in danger of genetic erosion.

Prospects *Persicaria senegalensis* is an interesting species, meriting more research to evaluate its nutritional, medicinal and ornamental values.

Major references Burkill, H.M., 1997; Dossaji, S.F., Kairu, M.G., Gondwe, A.T. & Ouma, J.H., 1977; Graham, R.A., 1958; Wilson, K.L., 1990.

Other references Cavaco, A., 1953; Decary, R., 1946; Hedberg, O., 2000; Jansen, P.C.M., 1981; Kerharo, J. & Adam, J.G., 1974; Kokwaro, J.O., 1993; Odei, M.A., 1973; Raponda-Walker, A. & Sillans, R., 1961; Raynal-Roques, A., 1978; Thulin, M., 1993b.

Authors P.C.M. Jansen

PHASEOLUS VULGARIS L. (French bean)

Phaseolus vulgaris – planted

Protologue Sp. pl. 2: 723 (1753).

Family Papilionaceae (Leguminosae - Papilionoideae, Fabaceae)

Chromosome number $2n = 22$

Vernacular names French bean, snap bean, navy bean, common bean (En). Haricot vert, haricot mange-tout (Fr). Vagem (Po). Mharagwe (Sw).

Origin and geographic distribution *Phaseolus vulgaris* was domesticated in Central and South America more than 6000 years ago. Domestication occurred independently in Mexico and Guatemala, and Peru and neighbouring countries. Small-seeded ecotypes occur in the wild in northern Argentina and Central America. Dry seeds were introduced and planted in Spain during the 16th century and from there *Phaseolus vulgaris* was taken to France. The unripe pods soon became popular as a vegetable in Europe. The use of the green pods was made possible by a considerable reduction of the 'parchment' consisting of cross-intersecting fibres in the fruit wall. This character, polygenic in heredity, was improved by breeding in Europe during the 18th and 19th centuries. The hard fibres along both sutures ('strings') were first eliminated by a dominant mutation, which appeared spontaneously during the 19th century. However, several genes control the presence of strings and this character is somewhat linked with pod straightness, and it is only recently that French bean with long and straight, consistently stringless pods have been bred successfully. At present French bean is produced all over the world and can be found in all countries of tropical Africa. It is more popular in Francophone than in Anglophone countries, more in urban than in rural areas, more in highland than in lowland regions, and more during the cool season than during the hot season.

Uses Young pods of French bean are boiled after cutting both ends and carefully removing the strings, if present; they may then be cooked or fried with sliced onion and garlic, or used in salads. They can be boiled together with rice. They require a shorter cooking time than dry bean seeds. The full-grown but immature seeds (larger than dry ones) are sometimes also eaten, and sold in their pods on vegetable markets. They can be cooked without previous soaking in water and in a shorter time than dry seeds. Leaves are occasionally used as a vegetable, but few cultivars have leaves of sufficient tenderness. Crop residues are often used as fodder.

In East and southern Africa the use of ripe seeds of *Phaseolus vulgaris* as a pulse is more important than the use of unripe pods or seeds as vegetables; a separate article in PROTA 1:

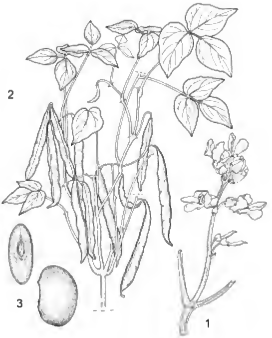
Cereals and pulses deals with pulse aspects of *Phaseolus vulgaris*.

Production and international trade World production of French bean (combined with yard-long bean) in 2002 was estimated by FAO at 5.8 million t from 855,000 ha. China produced 2.0 million t, Turkey 515,000 t, the European Union 664,000 t, tropical Africa about 75,000 t and northern Africa 312,000 t. An important part of the tropical African production is exported to Europe: nearly 40,000 t, the most important exporters being Senegal, Burkina Faso, Kenya and Zimbabwe. French bean is the third most important agricultural export product of Kenya, after only tea and pineapple.
The production of French bean pods for canning is important in Europe. An important amount of French bean seeds is produced in East African highlands (e.g. Kenya, Tanzania) for European seed companies.

Properties The nutritional composition of French bean pods, raw and ends trimmed (edible proportion 83%) is: water 90.7 g, energy 99 kJ (24 kcal), protein 1.9 g, fat 0.5 g, carbohydrate 3.2 g, dietary fibre 3.0 g, Ca 36 mg, Mg 17 mg, P 38 mg, Fe 1.2 mg, Zn 0.2 mg, carotene 330 µg, thiamin 0.05 mg, riboflavin 0.07 mg, niacin 0.9 mg, folate 80 µg, ascorbic acid 12 mg (Holland, B., Unwin, I.D. & Buss, D.H., 1991).

Adulterations and substitutes French bean pods used in dishes can be replaced by pods of several other leguminous crops. Yard-long bean (*Vigna unguiculata* (L.) Walp.) is the most appropriate substitute in tropical lowland, but in Africa its use is mostly restricted to consumers from Asian origin. Young pods of runner bean (*Phaseolus coccineus* L.) are also used as a substitute; the large pods are sliced before cooking. The young pods of lablab (*Lablab purpureus* (L.) Sweet) are also used in the same way as those of French bean.

Description Climbing, trailing or more or less erect and bushy annual herb, slightly pubescent; taproot well developed, with many lateral and adventitious roots; stem up to 3 m long, angular or nearly cylindrical. Leaves alternate, 3-foliolate; stipules triangular, small; petiole up to 15(–30) cm long, grooved above, distinctly thickened at base, rachis (1.5–)2.5–3.5(–6) cm long; stipels small; leaflets ovate, (5–)7.5–14(–20) cm × 5–10(–15) cm, basal ones asymmetrical, apical one symmetrical, entire, slightly pubescent, 3-veined from the base. Inflorescence an axillary or terminal raceme up to 15(–35) cm long, with flowers arranged along the rachis in pairs or solitary. Flowers bisexual, papilionaceous; pedicel up to 1 cm long, slender, with ovate bracteoles; calyx campanulate, tube c. 3 mm long, lobes triangular, 2–3 mm long; corolla white to pale purple or red-purple, standard very broadly obovate, hood-shaped, c. 1.5 cm long, wings obovate, c. 2 cm long, keel sharply upturned, c. 1 cm long; stamens 10, 9 fused and 1 free; ovary superior, c. 0.5 cm long, laterally compressed, style upturned and spiralled, with collar of fine hairs below the ellipsoid stigma. Fruit a linear pod up to 20 cm long, straight or more commonly curved with a prominent beak, fleshy when immature, green or yellow, sometimes red, purple or with purplish stripes, (2–)5–7(–9)-seeded. Seeds globose to kidney-shaped, ellipsoid or oblong, 0.5–1.5(–2) cm long, black, brown, yellow, red or white, sometimes with speckled, flecked or saddled patterns; hilum oblong to elliptical. Seedling with epigeal germination; cotyledons oblong, thick; first two leaves simple and opposite, subsequent leaves alternate, 3-foliolate.



Phaseolus vulgaris – 1, inflorescence; 2, fruiting branch; 3, seeds.
Source: PROSEA

Other botanical information *Phaseolus* comprises about 50 species, most of them in the Americas. Most French bean cultivars belong either to the climbing, unbranched 'pole' type, or to the dwarf 'bush' type. The pole cultivars have indeterminate growth up to 3 m high and

are normally supported. The bush cultivars are early maturing, 20–60 cm tall, and have determinate growth with short internodes. Stringless cultivars now predominate. The so-called 'wax beans' are yellow because chlorophyll is absent from the pods, petioles and young stems. Green French bean pods may be uniformly green, or purple-striped due to the presence of anthocyanins. Some cultivars produce uniformly purple pods (e.g. 'Mange-tout à cosse violette'). Purple striped and yellow pods are easier to pick by hand amongst the green foliage. Most French bean cultivars have cylindrical pods, but large flat stringless ones, called 'slicing bean', are popular especially for home gardening in Europe. Local African cultivars – genetic mixtures resulting from earlier introductions and often heavily infected with seedborne diseases – can be found where small-scale farmers keep their own seeds.

Growth and development For good seed germination, the soil must be warmer than 12°C, optimal growth occurring at 22–25°C. The plant can withstand occasional day temperatures of 35°C, which can, however, induce flower abortion. The roots form nodules containing nitrogen-fixing *Rhizobium* bacteria. Several *Rhizobium* species fix nitrogen with *Phaseolus vulgaris*, e.g. *Rhizobium phaseoli*. Flowering starts 28–35 days after sowing. Self fertilization is common and the rate of cross pollination by insects is generally small. Such hybrids are often easily recognized by differences in seed colour. Young pods can be harvested 15–20 days later. The harvest of the immature pods induces prolonged flowering. The harvest period can last 10–15 days to 20–30 days for bush and pole cultivars, respectively.

Ecology *Phaseolus vulgaris* is well adapted to elevations of 1500–2000 m in East Africa. It can, however, be grown under lowland conditions provided maximum daily temperatures are not higher than 30°C, as occurs during the dry winter season in the Sahel. Most French bean cultivars are sensitive to soil acidity and aluminium toxicity, the optimum pH is 6.1–7.6. In African regions where there is no *Phaseolus vulgaris* growing tradition, nitrogen fixation by *Rhizobium* spp. may be not efficient enough to ensure normal growth, also because modern cultivars are bred on European soils very rich in nitrates. French bean is sensitive to salinity and to excessive soil boron. In heavy clay soils germination problems may occur if irrigation is applied between sowing and emergence.

Propagation and planting Seed weight of French bean varies from 0.2–1 g. For bush cultivars, seeds are sown either following traditional triangular patterns, or more often nowadays in lines, with 20 seeds/m sown solitary or 4–5 together at 20–25 cm intervals, with 60–80 cm between lines. This requires about 100 kg seed/ha. Seeds of pole cultivars are sown 5–6 together in lines at intervals of 40–50 cm, with 100–120 cm between lines. The seeds are buried at 3–4 cm depth, or up to 7 cm if the soil surface is dry and the soil not too heavy. For climbing types, 2 m high poles (straight branches, bamboos or bars) are placed after emergence of the seedlings. In humid tropical conditions, it is recommended that they be placed vertically (rather than 2–4 tied together at the top) to avoid the development of web blight. In Kenya some farmers grow French bean for export in hydroponics in screen-houses.

Management An average fertilizer recommendation for French bean is about 40 kg N, 90 kg P and 90 kg K per ha for bush cultivars, and 60 kg N, 120 kg P and 120 kg K for pole cultivars, depending on the soil fertility situation. As the growth of the root system is slow, it is recommended that some nitrogen fertilizer be applied even where effective nodulation can be expected. However, excess nitrogen will predispose the crop to bacterial blight and aphid infestation. In acid soils tricalcium phosphate may be applied in the furrow before sowing, in neutral or alkaline soils triple superphosphate. Direct contact between seed and fertilizer should be avoided. During the vegetative stage weeds must be rigorously controlled, but damage to the roots and stem base should be avoided. During this stage irrigation should be applied twice weekly if it does not rain. Overhead irrigation is recommended if certified disease-free seeds have been sown and if aphids and thrips are a problem. However, overhead irrigation should be avoided for French bean grown for seed production, since it may induce bacterial blight.

Diseases and pests All parts of the French bean plant may be attacked by one or more diseases and pests, the severity and incidence depending on location and season. Several seedborne diseases are widespread. In Africa *Phaseolus vulgaris* is affected by essentially the same diseases and pests that are found on other legumes such as *Cajanus cajan*, *Vigna subterranea* (L.) Verdc. and *Vigna unguiculata*. In seedlings damping off caused by *Pythium aphanidermatum* or *Rhizoctonia solani* can be

serious in excessively wet soils and particularly if seeds are not treated with appropriate fungicides. Older plants can be killed by several wilt-causing pathogens (*Sclerotium rolfsii*, *Macrophomina phaseolina*, *Fusarium solani* f.sp. *phaseoli* and by nematodes). Infestation with these diseases is generally severe in cases of repeated cultivation without crop rotation. Management of these soilborne diseases is very difficult. In Western countries pesticides for the control of some soilborne pathogens are commercially available. In Africa the control is by the use of soil amendments (including neem extracts for nematode control), long crop rotations, or leaving the land fallow for several seasons.

The seedborne diseases angular leaf spot (*Phaeoisariopsis griseola*), anthracnose (*Colletotrichum lindemuthianum*), common bacterial blight (*Xanthomonas campestris* pv. *phaseoli*) and halo blight (*Pseudomonas syringae* pv. *phaseolicola*) can cause serious losses in French bean crops. It is not possible to control bacterial blight once established. Copper sprays can only minimize further spread and provide limited protection to apparently healthy plants. The use of certified disease-free seed is critical in averting the introduction of these diseases into new fields. These diseases are aggravated by overhead irrigation and excessive nitrogen fertilization. Most modern French bean cultivars are resistant to common races of *Colletotrichum*. It is possible to effectively control angular leaf spot and anthracnose by seed dressing and by fungicide sprays.

Other diseases that can cause serious crop losses are bean rust (*Uromyces appendiculatus* var. *appendiculatus*), powdery mildew (*Erysiphe polygoni*) and web blight (*Rhizoctonia solani*). Some cultivars are relatively resistant to bean rust. Application of fungicides may be necessary if bean rust or powdery mildew infections occur during the early stages of growth.

Most French bean cultivars on the market nowadays are resistant to bean common mosaic virus (BCMV, aphid-transmitted and seedborne). In tropical lowlands where common bean is grown together with cowpea, legume strains of cucumber mosaic virus (CMV) and several cowpea viruses transmitted by beetles have been observed on French bean. The control of BCMV is based on the use of certified disease-free seed, resistant cultivars and vector management.

The most important insect pests during the first 4 weeks of growth are bean flies (*Ophiomyia* spp.), which tend to be severe during dry spells after a rainy season. Aphids (*Aphis fabae* and *Aphis craccivora*) can also be a problem at early growth stages. Both bean flies and aphids can be effectively controlled by seed treatment with systemic insecticides such as imidacloprid. In Africa cutworms (*Agrotis* spp.) and caterpillars (*Spodoptera* spp.) may be a problem especially in soils amended with farmyard manure. Important pests of older plants include thrips (*Frankliniella occidentalis*, *Frankliniella schultzei* and *Megalurothrips sjostedti*), pod borers (*Helicoverpa armigera* and *Maruca testulalis*) and spider mites (*Tetranychus urticae*). Thrips, particularly *Frankliniella occidentalis*, are very difficult to control as they are resistant to many commonly used pesticides. Pod borers are easily controlled by *Bacillus thuringiensis* products. Spider mites are generally severe during the hot, dry season and in many cases are a result of excessive application of foliar pesticides early in the season.

Integrated pest management (IPM) strategies for French bean production are centred on the concept of avoidance of foliar pesticide applications for as long and as much as possible. This should give natural control agents a chance to keep pest populations at low levels. The second principle is not to apply any pesticides after flowering to avoid the contamination of pods. IPM includes crop rotation with non-leguminous crops, the use of certified disease-free seed, seed treatment with a systemic fungicide and insecticide, e.g. carboxin and imidacloprid for control of damping-off diseases and bean flies respectively, and treatment of late-season pests such as thrips, pod borers and spidermites by insecticides.

Harvesting In Africa French beans are picked by hand, usually twice a week, resulting in 4 harvests for bush cultivars and 7–9 for pole cultivars. This gives higher yields and better quality than mechanical harvesting, which is predominant in Europe and requires not only costly machinery, but also the use of special cultivars that produce all pods at the same time and large plots of flat land.

Yield Under the best growing conditions, yields of 7–8 t/ha of French bean pods can be obtained with bush cultivars and 14–16 t/ha with pole cultivars. In case of seed production up to 1000 kg/ha dried seeds can be produced under average growing conditions.

Handling after harvest Sorting of young pods is needed to remove broken, malformed

and overripe pods. For the French market grading is done in two main grades – extra fine and fine pods. Extra fine ones should be very tender, seedless, with no strings and free from any defects; the width should be less than 6 mm and the minimum length 10 cm. The fine pods may have small seeds and be short with soft strings; the width should be 6–9 mm. Specifications of grades in other countries may differ somewhat. French bean pods are packed in corrugated cardboard boxes of 3 kg gross weight or in plastic pre-packs weighing 250, 500 or 1000 g.
Pre-cooling is done using forced air coolers at 7–8°C. At this temperature and a relative humidity of 95–100%, the pods can be stored for one to two weeks.

Genetic resources Most French bean cultivars are of European or North-American origin. Germplasm collections are kept by research institutes in Europe and North America, and catalogues of seed companies offer a considerable variability. The collection preserved by the Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia holds mostly pulse cultivars; it includes interesting potential parents for disease resistance, general tolerance or adaptability to adverse soil conditions, which could be introduced into French bean. Cultivars traditionally recommended for the tropics are the bush cultivars 'Contender' and 'Tendergreen', and the pole cultivars 'Kentucky Wonder' or 'Phénomène à rames'. These cultivars may also be replaced nowadays by more recent cultivars chosen after local experimentation and better adapted to tropical conditions (e.g. the bush cultivar 'Délinel'). In Indonesia 'Perkasa', selected by East-West Seed Company from local material, has good fruit setting under hot, humid lowland conditions, yielding up to 10 t/ha.

Breeding *Phaseolus vulgaris* is predominantly autogamous and cultivars are inbred lines. Cross-fertilization can occur when flowers are visited by *Xylocopes* (big, dark blue Hymenoptera) and can be detected in seedlots of the following generation by off-coloured seeds. Controlled hybridization is a delicate operation taking about 2 minutes per flower. New homogeneous lines can be obtained after 7–8 generations (2.5–3 years when 3 generations per year). When breeders make crosses between pulse cultivars and French bean cultivars, the polygenic nature of the absence of parchment makes 2 or 3 backcrosses necessary, while the dominant heredity of the stringless character may cause reappearance of strings in the progeny of the best F_2 or F_3 plants.
Interspecific crosses can be made with *Phaseolus coccineus* L. and *Phaseolus acutifolius* A.Gray (a drought resistant species from Central America), and resistance to *Xanthomonas phaseoli* has been introduced from these species. Powdery mildew resistance was found in *Phaseolus vulgaris* germplasm from Haiti.

Prospects French bean is an important vegetable with high nutritional value and economic potential. It is of interest for family gardens (pole cultivars), the domestic market and the export market. It would be interesting to improve local cultivars with disease resistances (in addition to resistance to anthracnose and bacterial blight already obtained in Europe and the United States), proper fruit setting at high temperatures for adaptation to tropical lowland conditions, improved nitrogen fixation and adaptation to adverse soil conditions, using genes available from tropical pulse cultivars.

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PISUM SATIVUM L.

Protologue Sp. pl. 2: 727 (1753).

Family Papilionaceae (Leguminosae - Papilionoideae, Fabaceae)

Chromosome number $2n = 14$

Vernacular names
- Field pea, split pea (En). Pois, pois sec (Fr). Ervilha (Po). Njengere, njegere (Sw).
- Garden pea, petit-pois (En). Petit pois (Fr). Ervilha (Po). Njengere, njegere (Sw).
- Sugar pea, pea pod, snap pea, snow pea, mange-tout (En). Pois mange-tout, pois gourmand (Fr). Ervilha torta (Po).

Origin and geographic distribution The origin and progenitors of *Pisum sativum* are

Pisum sativum – planted

not well known. The Mediterranean region, western and central Asia, and Ethiopia have been indicated as centres of origin. Recently FAO designated Ethiopia and western Asia as centres of diversity, with secondary centres in southern Asia and the Mediterranean region. Archaeological evidence of the use of pea dating from 8000 BC has been found in the Fertile Crescent. The first cultivation of pea appears to have been in western Asia, from where it spread to Europe, China and India. In classical times Greek and Roman authors mentioned its cultivation as a pulse and fodder crop. Pea was already well known in the mountain regions of Central and East Africa before the arrival of the Europeans and was a well-established and important food crop in Rwanda and south-western Uganda by 1860. The use of the edible pods was first described in the Netherlands and France during the 16th century, whereas the use of immature seeds as a vegetable began in Europe a century later.

At present, *Pisum sativum* is found in all temperate countries and in most tropical highlands. Field pea is extensively grown in the highlands of eastern Central Africa and East Africa (notably Ethiopia), and in southern Africa. In parts of Rwanda and Uganda it is the main pulse crop. Field pea is hardly grown in West Africa. In Africa garden pea and sugar pea are mostly considered exotic products. They are regionally of some importance, sugar pea more in Francophone countries, garden pea more in Anglophone countries. Imported canned garden pea seeds are available everywhere in food shops.

Uses Three main types of pea cultivars can be distinguished: field pea, grown for the dry seeds; garden pea, grown for the immature green seeds; and sugar pea, grown for the immature pods. The dry seeds of field pea are first soaked in water to soften and are then boiled and consumed as a pulse dish. Alternatively, they are decorticated and split ('split peas') before boiling. They are also consumed roasted. The young pods of sugar pea are boiled for a few minutes only, to preserve their crispness; after boiling they may be stir-fried before consumption. The young seeds of garden pea are also boiled for a few minutes. They are commonly offered as canned or – in Western countries – as deep frozen products. In Ethiopia the annual consumption per person of pea seeds is estimated at 6–7 kg. Main dishes include 'shiro wot' (split pea seeds ground and made into stew) and 'kik wot' (split pea seeds boiled and made into stew). Snacks include 'eshet' (fresh green field pea seeds either eaten raw or roasted), 'nifro' (boiled dry or fresh green pea seeds) and 'endushdush' (seeds soaked first and then roasted). In local markets white- and cream-coloured seeds are preferred for 'kik'-making, and grey-coloured seeds for 'shiro'-making. In Malawi and some Asian countries, the young shoots are used as a leafy vegetable. In Western countries dry, mature pea seeds are extensively used as animal feed. The haulms or straw after threshing are used as forage, hay, silage and green manure. Apart from being an important source of food and feed, pea plays a role in soil fertility restoration as a suitable rotation crop that fixes atmospheric nitrogen.

Production and international trade FAO estimated the annual world dry pea seed production in 1999–2003 at about 10.5 million t from 6.2 million ha. The main producers are Canada (2.1 million t/year from 1.1 million ha), France (1.9 million t/year from 400,000 ha), China (1.1 million t/year from 900,000 ha) and the Russian Federation (1.1 million t/year from 700,000 ha). The annual production in tropical Africa for this period was about 310,000 t from 470,000 ha. Here, the main producers are Ethiopia (135,000 t/year from 184,000 ha), DR Congo (65,000 t/year from 96,000 ha), Burundi (32,000 t/year from 49,000 ha), Tanzania (28,000 t/year from 63,000 ha), Uganda (18,000 t/year from 29,000 ha) and Rwanda (14,000 t/year from 30,000 ha). The annual world production of green pea seeds in 1999–2003 was about 8.7 million t from 1.0 million ha, the main producers being India (3.4 million t/year from 300,000 ha), China (1.5 million t/year

from 190,000 ha) and the United States (1.0 million t/year from 96,000 ha). In tropical Africa about 30,000 t green pea seed was produced annually from 6400 ha, mainly in Kenya (23,000 t/year from 5600 ha).

Statistics on the international trade in pea seed are generally scanty, as they are mostly aggregated in 'pulse crops' as a whole. The main exporting countries are Canada, Australia, France and China. Canada focuses on the European stock feed market and in recent years on the food market in India. Australia focuses on the food markets and the domestic feed market. The top importers for pea feed or food are Spain, Bangladesh, Belgium, India, China, United States, Colombia, United Arab Emirates and Malaysia. Almost all the production in Ethiopia is consumed locally. Most sugar pea pods produced in the world are sold in local markets. Western countries import large quantities of sugar pea pods from developing tropical countries because locally produced ones are available for only a short time of the year and because of the high labour costs of picking. Kenya exports yearly 4500 t sugar pea pods to the European Union. Garden pea seeds are mostly exported as canned or frozen products from Western countries, e.g. the United States and France, but statistical data are not available.

Properties Whole mature dried seeds of field pea contain per 100 g edible portion: water 13.3 g, energy 1269 kJ (303 kcal), protein 21.6 g, fat 2.4 g, carbohydrate 52.0 g (starch 47.6 g), fibre 15.0 g, Ca 61 mg, Mg 120 mg, P 300 mg, Fe 4.7 mg, Zn 3.7 mg, carotene 245 μg, thiamin 0.6 mg, riboflavin 0.3 mg, niacin 3.0 mg, ascorbic acid trace. The composition of wrinkled pea seeds is different from rounded ones; they have less starch (27–37 g) and more fat (5 g) and sugars.

Raw garden pea seeds, immature taken from the pods (refuse 63%) contain per 100 g edible portion: water 74.6 g, energy 348 kJ (83 kcal), protein 6.9 g, fat 1.5 g, carbohydrate 11.3 g (starch 7.0 g), fibre 4.7 g, Ca 21 mg, Mg 34 mg, P 130 mg, Fe 2.8 mg, Zn 1.1 mg, carotene 300 μg, thiamin 0.75 mg, riboflavin 0.02 mg, niacin 2.5 mg, folate 62 μg, ascorbic acid 24 mg.

Raw sugar pea pods, with the ends trimmed (refuse 8%) contain per 100 g edible portion: water 88.7 g, energy 134 kJ (32 kcal), protein 3.6 g, fat 0.2 g, carbohydrate 4.2 g (starch 0.8 g), fibre 4.2 g, Ca 44 mg, Mg 28 mg, P 62 mg, Fe 0.8 mg, Zn 0.5 mg, carotene 695 μg, thiamin 0.2 mg, riboflavin 0.15 mg, niacin 0.6 mg, folate 10 μg, ascorbic acid 54 mg (Holland, B., Unwin, I.D. & Buss, D.H., 1991).

Description Annual, climbing, glabrous herb up to 200(–300) cm tall (up to 130 cm for sugar pea types); taproot well developed, up to 120 cm long, with many lateral roots; stem terete, with no or few basal branches, internodes hollow. Leaves alternate, pinnate, with 1–3(–4) pairs of leaflets and ending in a usually branched tendril; stipules leaf-like, up to 8(–10) cm × 4 cm; petiole (2–)4–6(–7.5) cm long; leaflets shortly stalked, ovate to elliptical, 1.5–8 cm × 0.5–4 cm, entire to toothed, sometimes converted into tendrils. Inflorescence an axillary, 1–3-flowered raceme. Flowers bisexual, papilionaceous; calyx with tube 4–8 mm long, lobes as long or longer than tube; corolla white to purple, standard 1–3 cm × 2.5–4.5 cm, wings a little shorter than standard, keel much shorter; stamens 10, 9 united and 1 free; ovary superior, 1-celled, style curved, longitudinally grooved. Fruit an oblong-ovate pod 3.5–15 cm × 1–2.5 cm, pendant, 2–11-seeded. Seeds globose, sometimes wrinkled, 5–8 mm in diameter, varying in colour from uniform yellow (sugar pea), green (crinkled garden pea) to purple or spotted or cream-white, sometimes with black hilum. Seedling with hypogeal germination;

Pisum sativum – 1, shoot with flower; 2, part of shoot with fruit; 3, seed.
Source: PROSEA

cotyledons remaining within testa; first 2 leaves simple.

Other botanical information *Pisum* comprises a few species and is related to *Lathyrus*, *Lens* and *Vicia*, from which it can be distinguished by its terete stems, very large stipules and longitudinally grooved style.

Pisum sativum has long been studied by geneticists; Knight did his crossing experiments on it in 1787, and it was the subject of the pioneering work of Gregor Mendel in the 19th century. Within *Pisum sativum* several varieties or subspecies have been distinguished. Var. *sativum* is cultivated worldwide, including tropical Africa. Var. *abyssinicum* (A.Braun) Alef. (Abyssinian pea) is cultivated in Ethiopia, from Tigray and Wollo in the north southwards to Shewa and Arsi; it is also grown in Yemen. It differs from var. *sativum* in having leaves with only one pair of leaflets (var. *sativum*: 2–3 pairs), and smaller, red-purple flowers. It has slightly glossy seeds with a black hilum; these may mature earlier. Other varieties or subspecies occur outside Africa; 2 of these represent wild populations from southern Europe and western Asia.

Purple coloured flowers are associated with bitter tasting green seeds. For this reason nearly all garden pea cultivars are white-flowered, while most field pea cultivars are purple-flowered and sugar pea cultivars can have white or purple flowers. The 'edible pod' character (absence of 'parchment' in the pod walls) is induced by two recessive genes. A mutation inducing thickening of this wall of up to 3 mm was recently introduced in American cultivars, giving rise to the 'sugar snap pea'. For field pea, mostly farm-saved seed of local cultivars is used in Africa; well-known cultivars are 'Mitali' and 'Miseriseri'. Well-known cultivars of sugar pea in Africa are 'Sugar Snap', 'Carouby de Maussane', 'Oregon Sugar Pod', 'Shield' and 'Sugar Queen'. Some cultivars of garden pea are 'Alderman', 'Télévision' and 'Green Feast'. Many growers use their own seed originating from old introductions. A peculiar mutant character, 'Afila', with tendrils in the place of leaflets has been introduced in commercial dwarf field pea cultivars.

Growth and development Pea seeds germinate at ambient temperatures of between 4–24°C, with 13–18°C being optimal. In sugar pea cultivars flowers appear between the 6th and 12th nodes according to cultivar earliness, normally 5–7 weeks after emergence. At optimum temperatures, pods are ready for harvesting 12 days later. For garden pea the duration of the flowering period is 2–3 weeks in cultivars for mechanical harvesting, up to one month in garden cultivars. For field peas the period from emergence to dry seed harvest ranges from 3–6 months depending on cultivar and environment. In a 2-season experiment with 63 genotypes in Ethiopia at 3000 m altitude, the period to flowering and maturity ranged from 80–104 days and 149–163 days, respectively. Pea flowers are self-pollinated, with usually less than 1% outcrossing. Pea is nodulated by *Rhizobium leguminosarum*.

Ecology Pea requires a relatively cool climate, with average temperatures between 7–24°C, and with optimum yields at average temperatures of 13–21°C, although maximum rates of development and vegetative growth are reached at considerably higher temperatures. It can be grown at elevations above 1000 m near the equator, or at lower elevations (even in coastal areas) during the cool season at latitudes between 15–20°. In tropical conditions sugar pea cultivars are generally considered more heat tolerant than cultivars grown for seed. Young plants can withstand frost if progressively hardened by lowering temperatures. *Pisum sativum* is grown in areas with an annual rainfall as low as 400 mm, but the optimum is 800–1000 mm/year. It is slightly susceptible to daylength, with long days promoting flowering. In most tropical circumstances it can be considered day-neutral. In Ethiopia rainfed field pea is grown at 1800–3000 m altitude, because it suffers from diseases and drought at lower altitudes and from frost at higher altitudes. It is mostly grown in the main rainy season. In Uganda pea plants grow best at altitudes above 1800 m, and in Kenya optimum yields are obtained at 2100–2700 m altitude. Pea grows on a wide range of soil types with moderate fertility levels, well drained and with pH 5.5–7.0, although some cultivars tolerate a pH up to 7.5. It is seriously affected by soil acidity, aluminium toxicity and waterlogging.

Propagation and planting Pea is propagated by seed. The 1000-seed weight ranges from 100 g to 500 g. Sugar pea is sown in double rows 10 cm apart with 60 cm (30–80 cm) between the double rows. Within the rows the seed of small cultivars is sown 3–5 cm apart, for taller cultivars up to 10 cm apart. Garden pea is sown rather dense, with plant densities up to 80 plants per m². The seed should be sown 4–7 cm deep. Per ha 60–200 kg of seed is required, with the highest rates for garden pea.

Field pea is mostly broadcast in Africa. Even though it does not require a fine seedbed as such, 2–3 ploughings with animal-drawn ploughs or one disc ploughing followed by two disc harrowings may be beneficial. Timely sowing is essential for optimum yields, since late-sown crops are often affected by low moisture availability and heavy aphid infestation at medium altitudes and by frost at high altitudes. In Ethiopia field pea is produced either as a sole crop or in mixed cropping with other crops, e.g. faba bean (*Vicia faba* L.). In the latter case, faba bean provides physical support and good aeration to field pea, whereas field pea suppresses weed growth. In Ethiopia mixed cropping of field pea with faba bean significantly slows down the rate of *Ascochyta* blight development and results in higher yields than pure stands. In the tropics, e.g. Rwanda and south-western Uganda, field pea is often the first crop after a fallow period. In temperate areas sugar pea is sown either in autumn or in early spring.

Procedures for direct as well as indirect, callus-mediated somatic embryogenesis have been developed for pea.

Management Sugar pea plants are normally supported. The stems are not twining, but grasp the support with their tendrils. They do not need vertical poles, but the poles can be crossed, or the plants are supported by wire mesh, horizontal wires, vertical lattices or nets, depending on the potential height of the cultivar grown. Garden pea is seldom supported, field pea not at all. Weeds should be rigorously controlled. The critical period of weed competition in field pea production is 3–8 weeks after emergence. Both annual and perennial grasses affect field pea. Weeds can be controlled by hand weeding where labour is cheap, whereas chemical weed control is more practical in large-scale production. Early land preparation can encourage weed seeds to germinate so that they can be destroyed in subsequent cultivation.

Field pea normally needs no fertilizer N as the amount present in the soil and fixed by the plant is sufficient. The total uptake of a crop yielding 5–6 t of seed per ha is 30–35 kg/ha P and 200–250 kg/ha K. Young sugar pea and garden pea respond well to a starter dose of N fertilizer, even when nodulation occurs. An indicative fertilizer recommendation on light medium-rich alkaline soils is 40 kg N, 50 kg P, 150 kg K and 30 kg Mg per ha. Irrigation is necessary in dry conditions, e.g. 10 mm twice a week.

Diseases and pests *Ascochyta* blight is a disease complex caused by *Ascochyta pisi*, *Mycosphaerella pinodes* (*Ascochyta pinodes*), and *Phoma medicaginis* (*Ascochyta pinodella*); it is widespread throughout the world. Moderate levels of resistance have been detected in landraces and in the related *Pisum fulvum* Sibth. & Sm., which occurs wild in western Asia. Powdery mildew caused by *Erysiphe pisi* initially forms small diffuse spots on the older leaves; these later coalesce and may cover the whole plant. Resistant cultivars have been developed. In sugar pea a recessive resistance gene is present in the cultivar 'Manoa Sugar' bred in Hawaii. Bacterial blight (*Pseudomonas syringae* pv. *pisi*) is common where pea is grown intensively and humidity is high. Although not yet recorded from Africa, downy mildew may develop at high altitudes where temperatures are between 1°C and 18°C. As *Ascochyta* blight, powdery mildew, bacterial blight and downy mildew are seedborne, the use of certified disease-free seed is essential. If own seed is to be used, it may be treated with a systemic fungicide to control *Ascochyta* blight and powdery mildew. In addition, wide row spacing, eradication of weeds, surface irrigation and rotations of three years or longer help to manage bacterial blight and other diseases. Aphid-transmitted virus diseases include bean yellow mosaic virus (BYMV), pea seedborne mosaic virus (PSbMV), pea leaf-roll (BLRV - bean leaf-roll luteovirus) and pea enation mosaic virus (PEMV). Recent sugar pea cultivars bred in southern France are relatively tolerant to severe infestation by these viruses (e.g. 'Supermangetout' compared to the traditional 'Carouby de Maussane').

Insect pests attacking pea include cut worms (*Agrotis* spp.), aphids (including the pea aphid *Acyrthosiphon pisum*, a vector of many virus diseases, which has become a major pest in Ethiopia), bollworms (*Heliothis armigera* and *Spodoptera exigua*) and the pea weevil (*Bruchus pisorum*). Bruchids (*Callosobruchus* spp.) are a major storage pest of field pea, e.g. in Ethiopia.

To control insect pests and diseases, integrated pest management (IPM) is recommended: use of resistant/tolerant cultivars; use of certified disease-free seed or seed treatment of own seed; keeping fields weed-free; appropriate fertilizing and irrigation; growing pea for seed in semi-arid and/or arid areas; regular monitoring of the crop; and judicious use of biocides.

Harvesting Sugar pea pods and garden pea seeds are ready for harvesting 8–12 weeks

from sowing, field pea seeds one month later. Pods of sugar pea are hand-picked every second day during a 15–20 day period. Garden pea seeds are either handpicked or – in large scale production for canning – machine-harvested. Late harvesting of field pea may result in shedding and rotting of pods and shattering of the seeds. Therefore, harvesting should be done at the appropriate stage: when the leaves begin to yellow, the lower pods begin to wrinkle, and the seed moisture content is reduced to 16–18%. In most parts of Africa where the time of harvest more or less coincides with the start of the dry season, it is easy to achieve low moisture contents while the crop is still in the field. Most field pea cultivars have an indeterminate growth habit and the pods do not mature simultaneously. Therefore, the harvested plants should be dried before threshing. In most parts of Africa (e.g. Ethiopia), harvesting of field pea is done with sickles, the crop is transported to threshing ground and stacked for a few days to dry in the sun. The stack is then spread on the ground and threshed usually by women or children or by trampling with animals.

Yield Yields of field pea range from less than 1 t/ha in Africa and South America to over 4 t/ha in Europe. The average world yield is around 1.7 t/ha. Under good growing conditions sugar pea yields of up to 8 t/ha edible pods per ha can be obtained. Garden pea may produce 4–7 t/ha young seeds.

Handling after harvest The initial seed moisture content of field pea must be reduced to the required level of about 12% before storage. Optimum moisture content reduces the deterioration rate during storage and prevents or reduces attack by moulds and insects. The seed should be stored in a dry and cool place, free of pests and protected from absorbing moisture from the surroundings. Sugar pea pods can be kept for only 2–3 days at temperatures of 20–25°C, but for more than 15 days at 2.5–5°C in perforated plastic bags or crates covered with perforated plastic sheets. Garden pea seeds may be kept for 1–3 weeks at temperatures of 0–4°C and a relative humidity of 88–92%.

Genetic resources A large genetic diversity has been found in *Pisum sativum* collections from both Africa (e.g. Ethiopia) and Asia (e.g. India). This diversity is not uniformly distributed across the major production areas. In Ethiopia collections from the southern half of the country (Arsi) were found to be more diverse for a number of attributes than collections from the northern half of the country (Gonder, Wollo and Gojam). Genetic erosion in field pea is probably less than in cereals, because of less progress in cultivar development and hence less replacement of landraces by a few new cultivars. Many germplasm collections of pea are held all over the world. The world collection of cultivars and mutant forms of *Pisum sativum* is housed at the Nordic Gene Bank, Alnarp, Sweden (about 2700 accessions). Emphasis in the collection is on lines with multiple disease resistance, wild and primitive types, lines carrying structural mutations, breeding lines and cultivars of special interest. Large *Pisum sativum* collections are held in Australia (Australian Temperate Field Crops Collection, Horsham, Victoria, 6300 accessions), the Russian Federation (N.I. Vavilov All-Russian Scientific Research Institute of Plant Industry, St. Petersburg, 6200 accessions), Italy (CNR - Istituto di Genetica Vegetale, Bari, 4100 accessions), the United States (Western Regional Plant Introduction Station, Pullman, 3500 accessions; Horticultural Sciences Department, NY State Agricultural Experiment Station, Geneva, 2500 accessions), China (Institute of Crop Germplasm Resources (CAAS), Beijing, 3400 accessions), and the United Kingdom (John Innes Centre, Department of Applied Genetics, Norwich, 2700 accessions). The largest collection of *Pisum sativum* germplasm in Africa is located at the Biodiversity Conservation and Research Institute, Addis Ababa, Ethiopia, with over 1600 accessions from altitudes of 1800–3350 m.

Breeding *Pisum sativum* is strictly autogamous and all commercial cultivars are pure lines. The main breeding objectives in temperate regions are colour and quality for fresh product markets and canning, mechanization and cold tolerance. Breeding in most parts of the tropics has an improved seed yield as a first priority through the development of productive cultivars tolerant/resistant to different stress factors and suitable for different agro-ecological conditions. Some progress has been made. In addition to improved yield potential, sources of resistance to powdery mildew have been identified. It is now generally believed that a single recessive gene controls resistance to this disease. Attempts to transfer resistance to *Ascochyta* blight from a wild type have not been successful because of complications due to polygenic behaviour and linkage with other agronomic traits. The presence of physiological races is another problem. Ma-

nipulation of morphological traits has resulted in determinate types with even maturity, suitable for mechanization and semi-leafless types with reduced lodging. Breeding efforts during the past three decades in Africa have resulted in the release of a number of cultivars (obtained by introduction, hybridization and local collection), but most farmers still use their own farm-saved seed of local cultivars. In Ethiopia more than 15 cultivars, with superior yield potential, seed size, seed colour and disease resistance, have been released for different agro-ecological conditions. These cultivars include 'Holetta' (from local collection), 'Tegegnech' (introduced from Burundi), 'Hassabe' and 'Markos' (introduced from the International Center for Agricultural Research in the Dry Areas, ICARDA) and 'Adi', 'Milky' and 'Wolmera' (obtained by hybridization of adapted local cultivars with introductions from the United States and ICARDA).

For sugar pea breeding the most urgent objective is powdery mildew resistance (available in 'Manoa Sugar') and to a lesser extent *Ascochyta* resistance (from green pea cultivars). The 'sugar snap' character will be interesting if it appears attractive to consumers. It might also be interesting to introduce more new characters into sugar pea, e.g. true dwarfs which could be grown without support, or climbing semi-leafless types in order to increase yields by higher plant densities and to make fruit picking easier.

A consensus genetic linkage map has been developed for *Pisum sativum* based on various linkage maps. Quantitative trait loci associated with lodging resistance, plant height and partial resistance to various diseases have been identified. Transgenic plants have been produced using *Agrobacterium*-based transformation vectors, e.g. to increase resistance to the pea weevil by incorporating α-amylase-inhibiting capacity.

Prospects Field pea will remain important in Central and East Africa, as well as in temperate areas. It is a major and cheap source of protein, fixes atmospheric nitrogen, and plays an important role in farming systems by breaking cereal monoculture. A drawback is its susceptibility to diseases, which can best be counteracted by the development of resistant cultivars. As a potential export crop, it might represent a special opportunity in the years to come. Sugar pea and garden pea will become gradually more important in city markets in tropical Africa. Sugar pea is often considered a tastier vegetable than French bean and it could be interesting to develop its production for the domestic African market and for export. Garden pea could be produced locally on a larger scale to replace imports in canned form.

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Sources of illustration Davies, D.R., 1989.

Authors C.-M. Messiaen, A.A. Seif, Mussa Jarso & Gemechu Keneni

POLYGONUM PLEBEIUM R.Br.

Protologue Prodr.: 420 (1810).

Family Polygonaceae

Chromosome number $2n = 20$

Synonyms *Polygonum herniarioides* Delile (1813), *Polygonum roxburghii* Meisn. (1856).

Vernacular names Small knotweed (En).

Origin and geographic distribution *Polygonum plebeium* is widespread all over tropical Africa, Asia and Australia. In some regions it is rare (e.g. DR Congo).

Uses *Polygonum plebeium* is eaten as a vegetable in Malawi, cooked with potatoes and groundnuts. The product is slimy but well liked because it has a good smell. In India it is used as a famine vegetable, and it is grazed by horses. In Australia crushed seeds are cooked

and eaten against bowel complaints; in India the roots are similarly applied.

Properties Dry *Polygonum plebeium* leaves contain per 100 g dry matter: protein 17 g, fat 3 g, carbohydrate 50 g, fibre 16 g, P 0.3 g (Hooper, D., 1904). When grown in dry places the leaves are said to be bitter. The fresh root contains 11% tannin, and oxymethylanthraquinone has also been isolated.

Botany Prostrate annual herb, much-branched, glabrous; stems up to 35 cm long, scabrid, red-brown, with short internodes. Leaves alternate, simple; ocrea cylindrical, up to 3 mm long, often silvery-white, irregularly fringed; petiole very short; blade very small, linear to obovate-elliptical, 1–2 cm × 2–5 mm, margin revolute, rather thick and leathery, dark green turning red. Inflorescence a congested raceme with short branches, forming axillary, 1–5-flowered clusters. Flowers bisexual; perianth 2 mm long, greenish, with 4 lanceolate-elliptical lobes 1.5 mm long, the outer pair keeled, white to pale pink; stamens 5–8; ovary superior, 1-celled, styles 3, free, 3 mm long. Fruit a trigonous nut up to 2 mm long, smooth, shiny black.

Ecology *Polygonum plebeium* occurs in drier locations than many other *Polygonum* species, such as rocky ground in dried riverbeds and drying mudflats along lakes, in eastern Africa usually at 600–2400 m altitude. It also grows as a weed in fields.

Management *Polygonum plebeium* is collected from the wild and is not cultivated.

Genetic resources and breeding *Polygonum plebeium* is very widespread and is not in danger of genetic erosion.

Prospects *Polygonum plebeium* will remain a locally important vegetable, particularly in times of scarcity. Its nutritive and medicinal properties need more research.

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Authors P.C.M. Jansen

PORTULACA OLERACEA L.

Protologue Sp. pl. 1: 445 (1753).

Family Portulacaceae

Chromosome number $2n = 18, 36, 54$

Vernacular names Purslane, garden purslane, pigweed (En). Pourpier, pourpier potager (Fr). Beldroega, bredo fémea (Po).

Portulaca oleracea – wild and planted

Origin and geographic distribution *Portulaca oleracea* is a cosmopolitan weed occurring especially in warm areas; it occurs throughout tropical Africa. The origin of its cultivation is uncertain, possibly western Asia or India. It is one of the oldest leafy vegetables, used from Europe to Japan, Australia and the Americas. It is eaten in many African countries, e.g. Côte d'Ivoire, Benin, Cameroon, Kenya, Uganda, Angola and South Africa. It is especially popular in Sudan and Egypt, where it is known in Arabic as 'rigla'.

Uses The succulent stems and leaves of purslane have a mildly acidulous pleasant flavour and are eaten in green salads or as a cooked vegetable. Purslane is also used as a potherb. It is occasionally pickled like gherkins or capers. The seed is also edible and is made into flour and porridge in Kenya.

Purslane has been used in folk medicine since ancient times and is included in the World Health Organization's list of most widely used medicinal plants. It is used as a diuretic, to treat rheumatism and gynaecological diseases, as a sedative, analgesic and cardiotonic, to treat fever, disorders of the urinary tract, intestinal worm infestation, as a tonic and choleretic, to treat dysentery, and as an external treatment for ulcers, eczema and dermatitis. Ash of purslane mixed with salt is taken to treat heart diseases. Purslane is also a source of livestock fodder.

Production and international trade Purslane is mainly collected from the wild or grown for home comsumption or local markets. Statistics on its production are rare; in Sudan it is

grown on about 3000 ha.

Properties Per 100 g edible portion (76%) purslane contains: water 93.9 g, energy 67 kJ (16 kcal), protein 1.3 g, fat 0.1 g, carbohydrate 3.4 g, Ca 65 mg, Mg 68 mg, P 44 mg, Fe 2.0 mg, Zn 0.2 mg, vitamin A 1320 IU, thiamin 0.05 mg, riboflavin 0.11 mg, niacin 0.48 mg, folate 12 μg, ascorbic acid 21 mg (USDA, 2002). The fat in the stems, leaves and seed is rich in the polyunsaturated linolenic acid. Purslane is reportedly rich in antioxidants. Oxalate and nitrate poisoning may occur if used in large quantities and people with a history of kidney stones should use it with caution. Purslane may even contain oxalates in quantities toxic to livestock. Goats given mainly or only purslane for food died within weeks. The entire plant contains the alkaloid norepinephrine. The red pigments in purslane are acylated betacyanins.
Aqueous extracts of purslane showed muscle-relaxing effects in chicken, rats and goats. Ethanolic extracts showed significant analgesic and anti-inflammatory effects. In tests with mice, a crude extract of purslane accelerated wound healing when applied topically. An ethanolic extract showed antifungal activity against *Trichophyton* dermatophytes. Extracts of the plant have shown antityrosinase activity and are being tested for their skin-whitening activity.

Adulterations and substitutes Single-flowered purslane (*Portulaca quadrifida* L.) and waterleaf (*Talinum triangulare* (Jacq.) Willd.) are used as substitutes for purslane.

Description Succulent, copiously branched, erect or prostrate annual herb; stem up to 50 cm long, glabrous but with hairs at the nodes when young, green to reddish or brownish. Leaves alternate to more or less opposite or in whorls on branchlets, simple; stipules absent; petiole 1–3 mm long; blade obovate to spatulate, 0.5–4 cm × 0.1–2 cm, cuneate at base, rounded at apex, entire. Inflorescence a sessile cluster at the branch tips, up to 8-flowered, often overtopped by branches growing from leaf axils. Flowers bisexual, regular; sepals 2, connate at base, ovate-triangular, 3–5 mm long, keeled; petals 5, adnate at base to sepals, broadly obovate, 3–8 mm long, yellow, emarginate; stamens 7–12, connate at base; ovary half-inferior, 1-celled, style with 3–6 arms. Fruit an ovoid capsule c. 4 mm long, circumscissile just below the middle, many-seeded. Seeds orbicular-reniform, 0.5–1 mm in diameter, black, smooth to tuberculate. Seedling with epigeal germination; hypocotyl 1–1.5 cm long, epicotyl absent; cotyledons elliptical-lanceolate, 5–7 mm long, succulent.

Portulaca oleracea – plant habit.
Source: PROSEA

Other botanical information *Portulaca* comprises about 150 species, of which about 30 occur in tropical Africa, but opinions on species delimitation differ considerably. *Portulaca oleracea* is variable, with diploid, tetraploid and hexaploid populations. Several subspecies have been distinguished, mainly based on seed size and seed-coat morphology. Cultivated plants have been distinguished as subsp. *sativa* (Haw.) Schübl. & Mart., being hexaploid ($2n$ = 54) and having a robust, erect habit and large seeds. These can best be distinguished as a cultivar group.

Growth and development Purslane completes its life cycle in the tropics in 2–4 months. Early growth is slow, but growth accelerates after 2 weeks. Shoots root readily at the nodes. Development seems not to be influenced by photoperiod. Flowering occurs early and year-round. Self-pollination in the bud is the rule. Fruits ripen in 7–12 days from flowering. The seed is easily dispersed by water and wind, with crop seeds or through bird droppings. *Portulaca oleracea* is characterized by the C_4-cycle photosynthetic pathway, which means it has a

high rate of photosynthesis at high light intensity and temperatures.

Ecology Purslane is a weed of fields and disturbed localities, and occurs also in open grassland and bushland, from sea-level up to 2400 m altitude. It is usually grown as a summer crop, requiring temperatures of 15–40°C with an optimum in some cultivars as high as 35°C. Frost is not tolerated. Near the equator it is grown up to an elevation of 1800(–2400) m. Purslane requires an ample supply of water from rainfall or irrigation. It is tolerant of a wide range of soils, but prefers sand or sandy loams. It is salt tolerant.

Propagation and planting Under natural conditions, purslane generally perpetuates itself by reseeding, but stem fragments also root easily after being cut. In cultivation, propagation is generally by seed. The seeds are very small, the 1000-seed weight being (0.1–)0.4–0.5 g, and the seed rate is about 20 kg/ha. Fresh seeds need light for germination, but this requirement disappears in older seeds. The depth of sowing markedly affects seed germination, planting at a depth over 6 cm inhibiting germination. It is recommended that the seed be sprinkled on the ground and covered lightly with compost. Planting is done in a seedbed with light soil.

Management Because purslane is shallowly rooted and grown as a densely planted, short-duration crop, the topsoil should be of good fertility. Organic manure is recommended at a rate of 20–30 t/ha at land preparation. As top-dressing 40 kg/ha of urea may be added 3 weeks after planting. Purslane requires regular watering at short intervals, 3–4 days in dry warm weather. It tolerates irrigation with saline drainage water. In Indonesia it is sometimes transplanted to a spacing of 30 cm × 30 cm and grown for a longer duration.

Purslane is often listed as one of the world's worst weeds, although others consider it not very harmful because of its shallow rooting. It is, however, an important host plant for root-knot nematodes. When controlling it in other crops, sprayed herbicides such as glyphosate and 2,4-D can be effective, but seeds may mature in the time it takes for a herbicide to kill the plant. It can also be controlled with the more environmentally friendly corn gluten meal. Purslane rarely develops in mulched areas, and mulch placed over purslane will usually smother it.

Diseases and pests No serious pests or diseases occur, but white rust (*Albugo* spp.) is common during the rainy season in Sudan. A common pest is the rigla gall weevil (*Baris lanata*) causing conspicuous galls. The lesser army worm (*Spodoptera exigua*) may attack new unfolding leaves. Whiteflies and aphids may also affect purslane.

Harvesting Harvesting can start 3–4 weeks after sowing, and 2–3 cuts at 2–3 week intervals are possible in commercial production. Cutting should be done low to stimulate new growth. Once-over harvesting by uprooting is also done. After 6–8 weeks flowering reduces the quality of the crop.

Yield In the tropics yields of 12–17 t/ha per crop have been reported; maximum yields reported are as high as 50 t/ha.

Handling after harvest Purslane can be stored in plastic boxes for 2–5 days at 0–1°C and high relative humidity.

Genetic resources The wide distribution of purslane indicates great genetic variability and flexibility, but few germplasm collections exist. In 1985 indigenous germplasm of *Portulaca oleracea* was collected in north-eastern Sudan.

Breeding Usually local landraces are cultivated in Africa, but some improved cultivars with larger leaves have been selected, e.g. 'Rumi' grown in Sudan. In Europe types with green leaves and yellow leaves are marketed.

Prospects Purslane is a nutritious leafy vegetable, and more attention should be given to improving production and marketing practices, e.g. production of clean rootless seedlings 6–8 cm long and packaged in trays covered with plastic film. Attention should also be given to collecting its germplasm.

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Sources of illustration Susiarti, S., 1993.

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PORTULACA QUADRIFIDA L.

Protologue Mant. pl. 1: 73 (1767).
Family Portulacaceae
Chromosome number $2n = 48$

Vernacular names Single-flowered purslane, small-leaved purslane, ten o'clock plant, chickenweed (En). Pourpier (Fr). Beldroega (Po). Kinyorwe (Sw).

Origin and geographic distribution *Portulaca quadrifida* is widely distributed in Africa and tropical Asia, and it has been introduced into the warmer areas of the Americas. In Africa it is found in all countries, usually as a weed, rarely cultivated (e.g. in DR Congo and Rwanda).

Uses The leaves and young shoots of *Portulaca quadrifida* are collected from the wild and are eaten raw. They have a mild pleasant flavour and are frequently used in salads. They are also consumed as a cooked vegetable. In India boiled leaves are mixed with sorghum or pearl millet flour in preparing a kind of bread. Plants are a good feed for pigs, chicken and other birds. Large types are sometimes planted as an ornamental (e.g. in Rwanda) or as a soil binder to prevent erosion (e.g. in Kenya). Medicinally *Portulaca quadrifida* is used less widely but has similar medicinal applications as *Portulaca oleracea* L. The general uses are as a diuretic, to treat rheumatism and gynaecological diseases, as a sedative, analgesic and cardiotonic, to treat fever, disorders of the urinary tract, worm diseases, as a tonic and choleretic, to treat dysentery, and to apply externally to ulcers, eczema and dermatitis.

Properties The nutritional composition of *Portulaca quadrifida* is probably comparable to *Portulaca oleracea*. *Portulaca quadrifida* may contain oxalates in toxic quantities, which may cause death in livestock. In some soils it also tends to accumulate nitrates and thus should be consumed in moderate quantities.

Botany Prostrate, mat-forming annual or short-lived perennial herb with much-branched, spreading, articulated, fleshy stems up to 30 cm long or longer, rooting freely from the nodes, often flushed reddish; nodes with a dense whorl of whitish hairs. Leaves opposite, simple, sessile, narrowly elliptical to ovate, 0.5–1.5 cm × 1–4 mm, apex obtuse to subacute, smooth, veins distinct. Flowers solitary at the tips of short lateral branches, surrounded by 4 involucral leaves and copious hairs, bisexual; sepals 2, ovate, 3(–6) mm long; petals 4, obovate, 3.5–10 mm × 4 mm, usually yellow (rarely pinkish); stamens 7–16, arranged in 1 whorl; ovary half-inferior, style usually with 4 arms. Fruit an obovoid capsule 2–3.5 mm long, dehiscing near the base leaving only a very thin persistent rim, many-seeded. Seeds semi-orbicular in outline, c. 1 mm in diameter, dull grey.

Portulaca comprises about 150 species, of which about 30 occur in tropical Africa, but opinions on species delimitation differ considerably. Particularly the group of species with alternate leaves is taxonomically difficult. *Portulaca quadrifida* is rather unique with its mat-forming habit, but it is very variable, particularly in stamen number and flower size. In Africa only *Portulaca pilosa* L. has a similar habit, but it has alternate leaves, 5 petals and more numerous stamens.

Like *Amaranthus*, *Portulaca* is characterized by the C_4-cycle photosynthetic pathway, which means a high rate of photosynthesis at high light intensity and temperatures. Fresh seeds need light for germination, but this requirement disappears in older seeds. Generative development seems not to be influenced by photoperiod. The flowers are said to open promptly at 10 a.m., hence the English name 'ten o'clock plant'. Seeds of *Portulaca quadrifida* are easily spread by wind, water, with crop seeds or through bird droppings, and as a weed it is difficult to control because it also easily propagates from small fragments.

Ecology *Portulaca quadrifida* is found in the wild on bare patches and among rocks, on sandy or stony soils, from sea-level up to 2000 m altitude. It is often involuntarily introduced by the agency of man and readily occupies newly disturbed areas, compost and rubbish heaps and fields. In some African languages it is called 'Lord of the rubbish heap'. It is tolerant of a wide range of soils but prefers sand or sandy loams.

Genetic resources and breeding The wide distribution and large variation of *Portulaca quadrifida* points to great genetic flexibility that rapidly permits adaptation to new environments.

Prospects *Portulaca quadrifida* will remain a minor vegetable, only of importance when other vegetables are scarce. Its nutritional composition and medicinal properties deserve further investigation. Cultivation can not be recommended because it also can behave as an aggressive weed.

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A.B., Ssegawa, P. & Birnie, A., 1999; Phillips, S.M., 2002; Susiarti, S., 1993.

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Authors P.C.M. Jansen

POUZOLZIA GUINEENSIS Benth.

Protologue Hook., Niger Fl.: 518 (1849).

Family Urticaceae

Synonyms *Pouzolzia abyssinica* (A.Rich.) Blume (1856), *Pouzolzia dewevrei* De Wild. ex Th.Dur. (1900), *Pouzolzia golungensis* Hiern (1900).

Origin and geographic distribution *Pouzolzia guineensis* is distributed from Senegal south to Angola and east to Ethiopia and Tanzania.

Uses In DR Congo the leaves are eaten as a cooked vegetable. Medicinal use of the leaves in DR Congo comprises wound healing and curing stomach-ache. In Côte d'Ivoire asthma is treated with a mixture of leaves kneaded with kaolin, leaf sap is taken to treat diarrhoea and dysentery, and a leaf decoction is given by draught against vomiting during pregnancy. A decoction of the whole plant is taken as an aphrodisiac.

Properties A trace of alkaloid has been reported in the leaf, but otherwise no phytochemical information is available on *Pouzolzia guineensis* or other species of the genus.

Botany Annual or short-lived perennial herb 1(–2) m tall, branched. Leaves alternate, simple; stipules free, up to 7 mm × 1 mm; petiole up to 3(–5) cm long; blade lanceolate to ovate, 1.5–9.5 cm × 0.5–3.5 cm, base cuneate, truncate or rounded, apex acuminate, margin entire, with 4–5 pairs of lateral veins. Inflorescence an axillary glomerule consisting of 1–2(–3) female flowers and a variable number of male flowers. Flowers unisexual, regular, small; male flowers on c. 0.5 mm long pedicel, 4(–5)-merous, perianth globular, c. 1 mm in diameter; female flowers sessile, ovary superior, ovoid, enclosed in the perianth, stigma protruding. Fruit a compressed achene c. 2 mm long, surrounded by the persistent perianth.

Pouzolzia comprises about 50 species in the Old World tropics; it is in need of a thorough revision. *Pouzolzia guineensis* is variable and 2 different forms are recognized throughout its range. As transitional specimens exist, formal taxonomic recognition is not justified.

Ecology *Pouzolzia guineensis* is found in moist wooded grassland, often in the shade of trees, in riverine forest and disturbed areas, e.g. roadsides, fallow and cultivated fields, at 600–1300 m altitude. It is a considered a weed of especially tree crops (e.g. cacao, cola) and is a host of the cotton stainer, *Dysdercus superstitiosus*, a pest of cotton, rice and peanuts.

Genetic resources and breeding In view of its wide distribution *Pouzolzia guineensis* is not in danger of genetic erosion.

Prospects As a vegetable *Pouzolzia guineensis* will remain popular locally. The lack of interest in *Pouzolzia guineensis* and other representatives of the genus from pharmacologists is surprising, as medicinal use is common both in Africa and Asia. A taxonomic revision of the genus might help as a basis for sound pharmacological work in the future.

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Other references Aké-Assi, L., 1984; Kerharo, J. & Bouquet, A., 1950; Mulyati Rahayu, 2001.

Authors C.H. Bosch

PRAECITRULLUS FISTULOSUS (Stocks) Pangalo

Protologue Bot. Zhurn. SSSR 29: 203 (1944).

Family Cucurbitaceae

Chromosome number $2n = 24$

Synonyms *Citrullus fistulosus* Stocks (1851), *Citrullus lanatus* (Thunb.) Matsum. & Nakai var. *fistulosus* (Stocks) Chakrav. (1982).

Vernacular names Tinda, squash melon, round melon (En). Tinda (Fr).

Origin and geographic distribution *Praecitrullus fistulosus* is cultivated as a vegetable in India, Pakistan and Afghanistan. The origin is probably north-western India, where wild types may still be found in the wild. In Punjab, Uttar Pradesh, Mumbay and Rajasthan it is quite important as a cultivated market vegetable. The Hindi name 'tinda' is commonly used in other parts of the world. In Africa it is cultivated locally, mainly in East Africa, as a vegetable for the Asian population. In Ghana and Kenya it is grown as an export commodity for the United Kingdom market. It is also grown on a small scale in the United States.

Uses The entire immature fruit is used as a

Praecitrullus fistulosus – planted

cooked vegetable. In India the fruits are also pickled and candied. The seeds are roasted and consumed in the same way as watermelon or egusi seeds. In India tinda is used as fodder and in medicine.

Production and international trade In Africa, tinda is usually grown in small plots for the market and only rarely for home consumption. The demand is primarily from people of Indian origin. There is some limited export, mainly from Kenya and more recently also from Ghana, to the United Kingdom. No statistical information is available on areas under production, market volumes and value. The information available indicates that the production of tinda in Africa is very limited, probably less than 50 ha per year.

Properties The composition of tinda fruits per 100 g edible portion is: water 93.5 g, energy 89 kJ (21 kcal), protein 1.4 g, fat 0.2 g, carbohydrate 3.6 g, fibre 1.6 g, Ca 25 mg, Fe 0.9 mg, P 24 mg, carotene 13 μg, thiamin 0.04 mg, riboflavin 0.08 mg, niacin 0.3 mg, ascorbic acid 18 mg (Holland, B., Unwin, I.D. & Buss, D.H., 1991).

Adulterations and substitutes In dishes tinda fruits can be replaced by bottle gourd, squash or similar cooked cucurbit fruits.

Description Monoecious, annual, climbing or trailing herb, with robust, villous hairy stem; tendrils 2–4(–5)-fid, slender. Leaves alternate, simple; stipules absent; petiole c. 6 cm long, hirsute; lamina ovate in outline, c. 15 cm long, shallowly pinnatifid, cordate at base, margin finely dentate, hispid hairy. Flowers usually solitary in leaf axils, comparatively small, c. 3 cm in diameter, regular, 5-merous, with short pedicel; calyx campanulate; petals connate, yellow, hairy; male flowers with 3 stamens; female flowers with inferior, globose, hairy ovary, stigmas 3. Fruit a globose or depressed-globose berry 6–12 cm in diameter, hispid when immature, glabrous when mature, pale to dark green outside, creamy white to pale green inside, many-seeded. Seeds ovate-oblong in outline, compressed, c. 8 mm long, with ridged margin, smooth, black.

Other botanical information *Praecitrullus* comprises a single species, which was formerly classified in *Citrullus*. However, it differs from species of this genus in its basic chromosome number and pollen morphology, and by the absence of urease in the seed. The fruit rind of tinda is thinner and softer than the usually solid and thick rind of watermelon and cooking melon. Crosses between *Citrullus* and *Praecitrullus* have not been successful. Molecular data confirm the separate position of *Praecitrullus fistulosus* and indicate a close relationship with *Benincasa hispida* (Thunb. ex Murray) Cogn.

Growth and development Emergence of the seedling takes 5–7 days from sowing. Germination is epigeal with full opening of the cotyledons after 10 days. The development is

Praecitrullus fistulosus – 1, part of flowering stem; 2, young fruit; 3, mature fruit.
Redrawn and adapted by Iskak Syamsudin

similar to that of watermelon, but the main branches of tinda are shorter, so that the plants are smaller. Male flowers open about one week before the female ones. Pollination is predominantly by bees. The fruits are ready to harvest in 13–15 weeks from sowing, depending on temperature and growing conditions.

Ecology Tinda is mainly cultivated in the lowlands, from sea-level up to approximately 1000 m altitude. It likes warm, sunny conditions of 25–30°C at daytime and 18°C or more during the night, and performs less well in cooler and humid areas. In India it is either grown in the dry season (February to end of April) or in the rainy season (mid-June to end of July). Tinda prefers light or sandy soils where its roots can penetrate easily. Moderately fertile to fertile soil is required for early closure of the vegetative cover.

Propagation and planting Seeds are sown directly on ridges or on flat land after the soil has been prepared either manually or mechanically by ploughing, harrowing or ridging. Tinda is primarily grown as a sole crop. Three or four seeds are sown per hill at a depth of 2–3 cm, spaced at approximately 90 cm × 150 cm. The seedlings are thinned to one or two per hill at 3–4 weeks after sowing when they have 2–4 true leaves. This leaves a plant population of about 10,000 plants per ha.

Management In case of prolonged drought, irrigation is required before ploughing. Fertilizer applications depend on the nutrient status of the soil. In general a fertilizer application at a rate of 50 kg N, 20 kg P and 20 kg K per ha is needed. Watering 2–3 times per week is recommended during the dry season. One or two weedings are required before the stems cover the soil, attained in 6–8 weeks after sowing. From this stage movement in the crop should be reduced to a minimum to avoid damaging the plants.

Diseases and pests The range of diseases that can be seen in tinda corresponds closely with that of watermelon. The most serious fungal diseases are downy mildew (*Pseudoperonospora cubensis*) and to a lesser extent powdery mildew (*Erysiphe cichoracearum* and *Sphaerotheca fuliginea*), which can be controlled by spraying a carbamate fungicide. *Choanephora cucurbitarum* causes wet rot of the fruit and another major disease of the fruit is anthracnose caused by *Colletotrichum gloeosporioides*. These diseases may be controlled chemically, e.g. by a weekly spraying with fungicides such as benomyl for 3–4 weeks. There are also several virus diseases that can cause severe fruit abortion, defoliation and fruit distortion. These viruses are usually transmitted by aphids (*Aphis* spp.), thrips and white flies (*Bemisia tabaci*). Virus infections can be reduced by spraying appropriate insecticides and by early planting before the heavy rains. The most serious pests are melon fruit fly (*Dacus* spp.) and leaf beetles (*Epilachna chrysomelina*), which can be controlled with insecticides.

Harvesting Tinda is harvested at the nearly mature green stage when the fruit has a diameter of 10–12 cm and the seed is still soft. Harvesting can take place about two weeks from fruit set, depending on prevailing moisture and temperature conditions. The fruit stalk is cut short to avoid damage to neighbouring fruits.

Yield Up to 4 fruits of about 500 g each can be harvested per plant. In India, an average yield of 10 t/ha is reported.

Handling after harvest Tinda fruits are usually packed in cardboard boxes to protect their skin, which is more delicate and softer than those of mature watermelon fruits.

Genetic resources A collection of 31 accessions is maintained at the Southern Regional Plant Introduction Station, Griffin, GA, United States.

Breeding Improved varieties have been developed by the Institute of Horticultural Research, Bangalore, India and by Punjab Agricultural University, Ludhiana, India. Breeding work focuses on earliness, tenderness of the fruit, fruit size and yield. 'Arka' and 'Dilpas' are cultivars introduced from India to Kenya. In India cultivars with dark green fruits and with pale green fruits are recognized, the latter being preferred.

Prospects Tinda is at present of minor importance in Africa, but growing may increase slightly for the city markets in East Africa and for export to the United Kingdom.

Major references Chadha, M.L. & Tarsem Lal, 1993; Choudhury, B., 1977; CSIR, 1950; Holland, B., Unwin, I.D. & Buss, D.H., 1991; Whitaker, T.W. & Davis, G.N., 1962.

Other references Hopkins, D.L. & Thompson, C.M., 2002; Nazimuddin, S. & Shaharyar H. Naqvi, S., 1984.

Sources of illustration Stocks, J.E., 1851.

Authors R.R. Schippers

PSOPHOCARPUS SCANDENS (Endl.) Verdc.

Protologue Taxon 17: 539 (1968).

Family Papilionaceae (Leguminosae - Papilionoideae, Fabaceae)

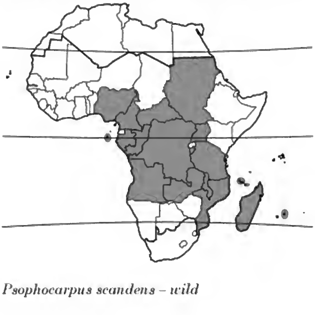
Chromosome number $2n = 18$

Synonyms *Psophocarpus longepedunculatus* Hassk. (1842), *Psophocarpus palustris* auct. non Desv.

Vernacular names African winged bean, tropical African winged bean, kikalakasa (En). Pois ailé africain, kikalakasa (Fr). Mabala (Po).

Origin and geographic distribution African winged bean is a common wild plant in Central and East Africa and the Indian Ocean islands, extending to eastern West Africa (Nigeria) and the northern part of southern Africa (Malawi, Zambia, Angola, Mozambique). It has been introduced in Jamaica and Brazil, where it is naturalized. A recent promotion campaign in DR Congo made it a quite popular vegetable for home gardens and a commercial crop for local markets, especially around Kinshasa. It was introduced as a cultivated leafy vegetable in several African countries, but acceptance was minimal, although the trials have been successful from the production point of view.

Uses The main product of African winged bean are the leaves and young sprouts, consumed as potherb. The immature fruits and ripe seeds are also eaten. In DR Congo African winged bean leaves are recommended as a galactagogue for women who are breastfeeding. The leaves made into a poultice are applied in the treatment of lumbago, wounds and haemorrhoids. A tea from the leaves is taken to relieve stomach-ache. *Psophocarpus scandens* is grown as a cover crop in Africa and Asia, e.g. in oil palm or rubber plantations, whereas the leaves mixed with other legumes and grasses are used as fodder.



Psophocarpus scandens – wild

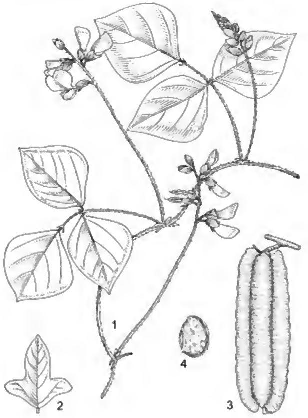
Production and international trade African winged bean is mainly collected from the wild, but it is grown in home gardens and in DR Congo also for local markets. No international trade is known to exist.

Properties In DR Congo young fresh leaves were found to contain per 100 g edible portion: water 82 g, protein 7.1 g, fat 2.2 g, carbohydrate 5.8 g, Ca 565 mg, P 65 mg, Mg 270 mg. The nutritional composition of young fruits per 100 g is: water 87 g, protein 3.6 g, fat 0.35 g, carbohydrate 7.3 g, Ca 297 mg, P 61 mg, Mg 200 mg (Harder, D.K., Lolema, O.P.M. & Tshisand, M., 1990).

Adulterations and substitutes The taste of eru (*Gnetum* spp.) is rather similar to the cheaper and more widely available African winged bean leaves.

Description Perennial climbing or twining herb; stem up to 6 m long, glabrous or sparsely pubescent. Leaves alternate, 3-foliolate; stipules oblong-lanceolate, 1–1.5 cm long, spurred, persistent; petiole 5–18 cm long, rachis 1–5 cm long; leaflets ovate-rhomboid to broadly rounded, 2.5–12 cm × 2–10 cm, cuneate to truncate at base, acute or acuminate at apex, occasionally 3-lobed, glabrous or glabrescent on both surfaces, margin often ciliate. Inflorescence a few- to many-flowered pseudoraceme; peduncle 3–40 cm long, rachis 5–12 cm long, pubescent; bracts semi-caducous, up to 1 cm long, bracteoles persistent, up to 1.5 cm long. Flowers bisexual, papilionaceous; pedicel 2–6 mm long, pubescent; calyx with tube 5–7 mm long, lobes unequal, up to 3.5 mm long; corolla with obovate-oblong standard up to 2 cm × 1.5 cm, pale blue or mauve, emarginate, blue-lilac wings and blue-lilac or whitish keel; stamens 10, 9 with fused filaments and 1 free or somewhat connate in the middle; ovary superior, oblong, 1-celled, style bent, with a row of hairs below the stigma. Fruit an oblong pod, square in cross-section, 3.5–8 cm × 6–7 mm, prominently 4-winged, glabrous, 4–8-seeded. Seeds oblong to cylindrical, (5–)6–7.5 mm × (3.5–)5–6 mm, blackish-purple, with minute granular, orange, easily removable tomentum or brown silky hairs on the edges. Seedling with epigeal germination.

Other botanical information *Psophocarpus* comprises about 10 species, one of which is only known from cultivation: winged bean, *Psophocarpus tetragonolobus* (L.) DC. The other species are all native to tropical Africa.



Psophocarpus scandens – 1, part of flowering stem; 2, lobed leaflet; 3, fruit; 4, seed.
Redrawn and adapted by Achmad Satiri Nurhaman

Psophocarpus scandens is closely related to *Psophocarpus palustris* Desv., which occurs from Senegal to Sudan. The latter species is also known as African winged bean and is still often confounded with *Psophocarpus scandens*. *Psophocarpus palustris* differs from *Psophocarpus scandens* in its leaflets which are usually more hairy beneath, its shorter bracteoles (up to 6.5 mm long) and usually shorter fruits (2.5–5.5 cm). In the region where the distribution areas of the two species meet (Nigeria to Sudan) some intermediate specimens, perhaps hybrids, have been found. Most agronomic information published under *Psophocarpus palustris* should be attributed to *Psophocarpus scandens*. However, *Psophocarpus palustris* is undoubtedly similarly used as a vegetable; the young fruits are eaten in Senegal.

Leaves and young pods of *Psophocarpus grandiflorus* R.Wilczek are eaten in DR Congo after boiling in water or milk. Roasted seeds are also eaten. Wooden statuary and artefacts are rubbed with the leaves to darken them. The strong shoots serve for tying purposes. A leaf infusion is given to induce labour in humans and cattle. *Psophocarpus grandiflorus* has larger flowers than *Psophocarpus scandens* and is restricted to high-altitude areas in eastern DR Congo, Ethiopia and Uganda.

Ecology In the wild, *Psophocarpus scandens* occurs in lowland areas up to 1000 m altitude, in DR Congo in regions with an annual rainfall of 1200–1800 mm and a mean annual temperature of 25°C. It prefers swampy localities, periodically flooded forest and river banks, but occurs also in drier localities, e.g. in grassland, thickets and fallow land.

Propagation and planting The seeds are very hard and can be kept for several years. They require scarification before planting. The weight of 100 seeds is 9–10 g. The spacing depends on the method of growing. When grown on flat land a distance of 50 cm × 50 cm is adequate; when allowed to climb fences, trellises or shrubs in the garden, one or two seeds are placed near the base of the support.

Management Early weeding is required as initial growth is slow. In DR Congo, people plant African winged bean on open land, often in association with sweet potatoes. It is also planted as a cover crop in agricultural systems with banana, maize, cassava, oil palm and rubber.

Diseases and pests *Psophocarpus scandens* is generally little affected by diseases and pests. It is resistant to several diseases and pests affecting *Psophocarpus tetragonolobus* such as false rust (*Synchytrium psophocarpi*) and dark leaf spot (*Pseudocercospora psophocarpi*). It is also less susceptible to necrotic mosaic virus and flower blight. The nematode *Heterodera marioni* attacks it in Mauritius and Sumatra (Indonesia). In DR Congo bruchid weevils attack the seed.

Harvesting The leaves are mainly picked before the plants set fruit.

Handling after harvest The leaves can be dried and powdered for long-term conservation. The seeds can be roasted and give good flour.

Genetic resources African winged bean is a common wild plant, which is not in danger of genetic erosion. The International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria and the Southern Regional Plant Introduction Station, Griffin, Georgia, United States hold collections of *Psophocarpus* germplasm including a few accessions of *Psophocarpus scandens*.

Breeding Efforts to cross *Psophocarpus scandens* with *Psophocarpus tetragonolobus*, which has the same chromosome number, have failed, probably because of differences in karyo-

type. If interspecific hybrids can be obtained, they will probably be sterile, so it will not be easy to transfer genes for disease and pest resistance from *Psophocarpus scandens* to *Psophocarpus tetragonolobus*.

Prospects African winged bean is a nutritious and easy to grow vegetable. There is a need for breeding of improved cultivars, together with research on cultural practices.

Major references Harder, D.K., Lolema, O.P.M. & Tshisand, M., 1990; Latham, P., 2002; Maxted, N., 1990; Maxted, N., 1991; Paulus, J., 1997; Pickersgill, B., 1980a; Schippers, R.R., 2002a; Verdcourt, B. & Halliday, P., 1978; Wulijarni-Soetjipto, N., 1997.

Other references Drinkall, M.J. & Price, T.V., 1986; Gunasekera, S.A., Shanthichandra, W.K.N. & Price, T.V., 1990; Harder, D.K., 1992; Klauer, S.F., Franceschi, V.R., Ku, M.S.B. & Zhang, D.-Z, 1996; Mackinder, B., Pasquet, R., Polhill, R. & Verdcourt, B., 2001; Mulongoy, K. & Akobundu, I.O., 1992; Tong, T.H., Tjong, J.K. & Lubis, I.P., 1961.

Sources of illustration Verdcourt, B. & Halliday, P., 1978.

Authors R.R. Schippers

PSOPHOCARPUS TETRAGONOLOBUS (L.) DC.

Protologue Prodr. 2: 403 (1825).

Family Papilionaceae (Leguminosae - Papilionoideae, Fabaceae)

Chromosome number $2n = 18$

Vernacular names Winged bean, wing bean, asparagus pea, Goa bean (En). Pois carré, haricot ailé (Fr). Fava de cavalo (Po).

Origin and geographic distribution *Psophocarpus tetragonolobus* is known only in cultivation; truly wild specimens have never been found. The greatest diversity is found in New Guinea and the hills of north-eastern India and neighbouring Myanmar (Burma), which are probable centres of domestication. Since the 1960s winged bean has been promoted strongly by international organizations as a multipurpose crop, and it has been introduced and tested in research stations in most countries of the tropics including those in tropical Africa. Yet at present it is only rarely found in home gardens or cultivated by farmers.

Uses Immature fruits are most commonly used for consumption. They are tender but insipid and less appreciated than French bean or yardlong bean. The consumption of young leaves is quite common in Asia, either cooked or in salads. In Myanmar (Burma) and New Guinea, special cultivars are grown for the tuberous roots resembling small sweet potatoes. The international promotion of winged bean in research and extension focused on the nutritional value of the dry seed as a pulse, but this has not led to wide use. Much research has been devoted to processing and use of winged bean flour, e.g. as a protein supplement in bread-making and as animal feed. The seeds can be used for making edible oil, milk and fermented products similar to soya bean products, and the whole plant as well as processed seeds are good animal feed. Winged bean is sometimes found as an ornamental because of its attractive flowers. In tropical Africa these uses are rare. In fact only the use of the green fruits and occasionally leaves and dry seeds is relevant for tropical Africa.

Production and international trade Winged bean is locally grown in home gardens in some African countries for domestic consumption. No data on production or trade are available.

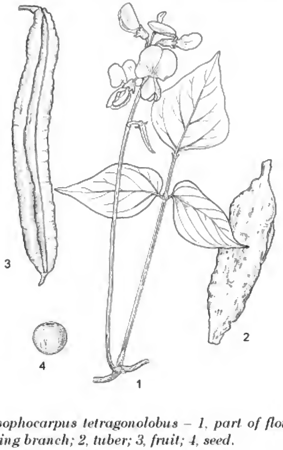
Properties The composition of young fruits per 100 g edible portion is: water 90 g, energy 113 kJ (27 kcal), protein 2.6 g, fat 0.5 g, carbohydrate 4.9 g, fibre 1.9 g, Ca 64 mg, Mg 34 mg, P 37 mg, Fe 0.8 mg, vitamin A 332 IU, thiamin 0.21 mg, riboflavin 0.1 mg, niacin 0.8 mg, ascorbic acid 15 mg (Rubatzky, V.E. & Yamaguchi, M., 1997). The composition of leaves per 100 g edible portion is: water 76.9 g, energy 310 kJ (74 kcal), protein 5.9 g, fat 1.1 g, carbohydrate 14.1 g, Ca 224 mg, Mg 8 mg, P 63 mg, Fe 4.0 mg, Zn 1.3 mg, vitamin A 8090 IU, thiamin 0.8 mg, riboflavin 0.6 mg, niacin 3.5 mg, folate 16 µg, ascorbic acid 45 mg. The composition of mature dry seeds per 100 g edible portion is: water 8.3 g, energy 1712 kJ (409 kcal), protein 29.7 g, fat 16.3 g, carbohydrate 41.7 g, Ca 440 mg, Mg 179 mg, P 451 mg, Fe 13.4 mg, Zn 4.5 mg, vitamin A 0 IU, thiamin 1.0 mg, riboflavin 0.45 mg, niacin 3.1 mg, folate 45 µg, ascorbic acid 0 mg. The composition of the tubers per 100 g edible portion is: water 57.4 g, energy 620 kJ (148 kcal), protein 11.6 g, fat 0.9 g, carbohydrate 28.1 g, Ca 30 mg, P 45 mg, Fe 2.0 mg, vitamin A 0 IU, thiamin 0.4 mg, riboflavin 0.15 mg, niacin 1.6 mg, folate 19 µg, ascorbic acid 0 mg (USDA, 2002).

The food value of winged bean fruits is comparable to that of French bean and yardlong bean, and that of the leaves to other dark green leafy vegetables. The composition of the seed is comparable to soya bean, its amino acid spectrum being similar. Improved cultivars with up to 37% protein in the seed exist. The lysine and

threonine content is high, while methionine and cystine are limiting amino acids. The oil resembles that of groundnut. Oleic and linoleic acids make up about 67% of the total fatty acid component and saturated fatty acids 29%. The easily refined oil is reasonably stable, with a high tocopherol content.
The seed contains several potent proteinase inhibitors active e.g. in *Heliothis armigera*. It has been suggested that transfer of the relevant genes to other crops may make these resistant to the caterpillar, for which chemical control is becoming increasingly difficult.

Adulterations and substitutes In vegetable dishes other leguminous fruits may as well be used, e.g. pods of French bean, pea, cowpea or yardlong bean. The dry seeds may be replaced by soya bean, lima bean, cowpea or other pulses. The edible leaves of the wild and cultivated African winged bean (*Psophocarpus scandens* (Endl.) Verdc.) can be used as substitutes for the leaves of winged bean.

Description Perennial climbing or twining herb, usually grown as an annual; roots numerous, with long lateral roots running horizontally at shallow depth, and some becoming thick and tuberous; stem up to 4 m long, ridged stipules ovate-lanceolate, c. 1 cm long, spurred,



Psophocarpus tetragonolobus – 1, part of flowering branch; 2, tuber; 3, fruit; 4, seed.
Source: PROSEA

and glabrous. Leaves alternate, 3-foliolate; persistent; petiole 3–12 cm long, rachis 1.5–5.5 cm long; leaflets ovate-triangular, 4–15 cm × 3.5–12 cm, truncate to rounded at base, acute at apex, glabrous or glabrescent on both surfaces. Inflorescence a 2–10-flowered pseudoraceme; peduncle 5–15 cm long, rachis 1–10 cm long, slightly pubescent; bracts semicaducous, minute, bracteoles persistent, up to 0.5 cm long. Flowers bisexual, papilionaceous; pedicel up to 5 mm long, slightly pubescent; calyx with tube 4–6 mm long, lobes unequal, up to 2 mm long, green to dark red-purple; corolla blue, mauve, creamy or reddish, with almost circular to broadly oblong standard up to 4 cm × 3.5 cm, emarginate, wings and keel slightly shorter; stamens 10, 9 with fused filaments and 1 free or somewhat connate in the middle; ovary superior, oblong, 1-celled, style bent, with a row of hairs below the stigma. Fruit an oblong to linear-oblong pod, square in cross-section, 6–40 cm × 2–3.5 cm, prominently 4-winged, glabrous, 5–21-seeded. Seeds almost globose, 0.5–1 cm in diameter, yellow, brown or black, sometimes white, sometimes mottled, glabrous, with a small aril. Seedling with epigeal germination.

Other botanical information *Psophocarpus* comprises about 10 species, all native to tropical Africa, except *Psophocarpus tetragonolobus*. Some authors consider the wild *Psophocarpus grandiflorus* R.Wilczek, others *Psophocarpus scandens* (Endl.) Verdc. (African winged bean), as progenitor of *Psophocarpus tetragonolobus*. *Psophocarpus palustris* Desv. is also closely related. However, it has also been suggested that *Psophocarpus tetragonolobus* developed from an extinct wild Asian species. It is characterized by its comparatively large flowers, short bracteoles and glabrescent leaves, and by its often long fruits.

Growth and development Emergence of the seedling under field conditions occurs 5–7 days after sowing. Temperatures around 25°C appear most suitable for germination and growth. The fibrous root system with large N-fixing nodules (up to 1.5 cm in diameter) grows in proportion to the shoot until about 3 months after planting. In tuberous cultivars, increases in root dry weight continue beyond the 6th month after planting. After about 2 months the plants start flowering, although some local cultivars require as long as 5 months. The flowers are mostly self-pollinated. Fruit development is not greatly affected by environmental conditions. Maximum fruit length and

maturity occur about 20 days and 65 days after pollination, respectively.

Ecology Winged bean is best adapted to equatorial climates. It is cultivated from sea-level up to 2000 m altitude, but does not tolerate night frost. Day temperatures of 25–32°C and night temperatures above 18°C are optimal for growth and reproductive development. Tuber initiation is favoured by cooler conditions. Winged bean requires at least 1000 mm annual rainfall, but is intolerant to waterlogging. Winged bean is a quantitative short-day plant, flower induction requiring a critical daylength of around 12 hours. The response to daylength varies with genotype, temperature and light intensity; some cultivars are day neutral. Winged bean thrives on a range of soil types with a pH above 5.5.

Propagation and planting Winged bean is normally propagated by seed, but tubers may also be used. The seeds are very hard and can be kept for several years, but old seed requires scarification before planting. Sowing 2–3 seeds per hole can be practised on raised beds; spacings are 40–60 cm in the row and 90–100 cm between rows. The 1000-seed weight is about 250 g; seed requirement 10–15 kg/ha. In home gardens winged bean is sown against walls, fences, trees or shrubs, and it may climb up to several metres high. Adequate drainage is essential and under wet conditions raised beds may be necessary.

Management One or two weedings in the first 4–6 weeks are needed as early growth is slow. Staking is necessary; the yield is reduced to less than half if plants are grown creeping. In gardens winged bean is grown against stakes or trellises of about 2 m high. Irrigation is needed during periods of prolonged drought. Winged bean is known to nodulate profusely in symbiotic association with *Rhizobium*. In a well-nodulated crop, nitrogen application is not necessary. However, in soils low in nitrogen, small quantities of N fertilizer may be applied at planting. Winged bean needs fertile soil, and appropriate fertilizing with P and K is needed. Mulching is recommended in dry conditions.

Diseases and pests Winged bean is not much affected by pests and diseases, and chemical spraying or other control measures are rarely applied. False rust or orange gall (*Synchytrium psophocarpi*) is perhaps the most widespread and damaging fungus. Cultivar resistance has been reported. Dark leaf spot (*Pseudocercospora psophocarpi*) is serious in hot humid areas. Powdery mildew (*Erysiphe cichoracearum*) occurs in cooler areas during periods of high air humidity in the dry season. Other diseases are web blight (*Rhizoctonia solani*) and flower blight (*Choanephora cucurbitarum*). Ring spot mosaic virus and necrotic mosaic virus were identified on winged bean in Côte d'Ivoire. Root-knot nematodes (*Meloidogyne* spp.) may cause stunted growth and yellowing of leaves. Amongst insect pests, bean pod-borer (*Maruca testulalis*) and various leaf-feeding caterpillars, bugs and cicadellids have been reported.

Harvesting Fresh fruits are harvested when they reach about 80% of their full length, once or twice per week for several months. The leaves are mainly picked before the fruit setting period. Harvesting the mature seeds needs many rounds of picking of the dry fruits at regular intervals because fruit ripening occurs over a long period and the fruits split and shatter seeds when they remain too long on the plants. Tubers are harvested at the first signs of senescence of the crop.

Yield Green fruit yields range from 10–15 t/ha, but up to 35 t/ha has been reported. Seed yield estimates from farmers' crops reach 800–1500 kg/ha; experimental yields of more than 2 t/ha have been reported, with a maximum of 4.5 t/ha in an experiment in Malaysia. Tuber yield in farmers' plots in Papua New Guinea was estimated at 5.5–12 t/ha.

Handling after harvest Freshly harvested green fruits store poorly and should be marketed within 24 hours. Storage in a cool room at 10°C and a relative humidity above 90% is possible. The leaves can be dried for long-term conservation. The dry seeds store very well, better than most pulses, due to their resistance to common storage insect pests. Tubers can be kept for up to 2 months, but they are normally consumed soon after harvesting.

Genetic resources Large germplasm collections have been made from most parts of southern and eastern Asia and New Guinea. Collections are available at the National Bureau of Plant Genetic Resources (NBPGR), New Delhi, India, holding about 1100 accessions of *Psophocarpus*, the National Plant Genetic Resources Laboratory (IPB/UPLB), Los Baños, the Philippines (about 900 accessions), the Department of Genetics and Cellular Biology, University Malaya, Kuala Lumpur, Malaysia (about 450 accessions) and the Department of Agriculture, Papua New Guinea University of Technology, Lae, Papua New Guinea (about 450 accessions).

Breeding Several cultivar trials, but no breeding have been recorded for winged bean in tropical Africa. In Asia many local cultivars of the vegetable type occur. Several improved cultivars are available from the above mentioned institutes, but mainly for use as a pulse crop. Breeding objectives depend on the product for which winged bean is raised. As a green vegetable crop, early flowering, high fruit yield and production over a longer period of time, green fruit colour, less fibrousness (reduced parchment layers) and a better taste are desirable. As a pulse crop, important objectives are early flowering, synchronization of fruit maturity, senescence at the end of the growing season, high seed yield, low shelling percentage, high protein and oil content depending upon the processing needs, and white seed colour. For a tuber crop, selection for low fruit yield, vigorous vegetative growth, high tuber yield and tuber quality factors including high protein and low fibre content and acceptable flavour are relevant. Attempts to realize interspecific hybridization with other *Psophocarpus* species have been unsuccessful so far.

Prospects The introduction of winged bean as new pulse crop or as a multipurpose vegetable in tropical Africa was not successful, some reasons being the climbing plant habit needing staking, the bothersome seed harvesting and the seed shattering and seed hardness. These characteristics make winged bean less interesting than traditional pulses like cowpea and introduced pulses like soya bean and common bean. For consumers winged bean fruits are less attractive than yardlong bean and French beans because of the bland taste. Yet, winged bean as vegetable merits some attention as a nutritious and easy to grow garden crop, especially suited for home gardens.

Major references Eagleton, G.E., Khan, T.N. & Erskine, W., 1985; Harder, D.K. & Smartt, J., 1992; Khan, T.N., 1982; Khan, T.N., 1993; Mnebuka, B.V. & Eggum, B.O., 1995; Rubatzky, V.E. & Yamaguchi, M., 1997; Tindall, H.D., 1983; USDA, 2002a; Verdcourt, B. & Halliday, P., 1978.

Other references Asare, E., 1984; Eagleton, G., 1999; Giri, A.P., Harsulkar, A.M., Ku, M.S.B., Gupta, V.S., Deshpande, V.V., Ranjekar, P.K. & Franceschi, V.R., 2003; Kemevor, G.L.A., 1980; Kpodo, C.M., 1987; Trèche, S., Tobias, J.F., Noubi, L., Pasquet, R. & Fotso, M., 1986.

Sources of illustration Khan, T.N., 1993.

Authors G.J.H. Grubben

Based on PROSEA 8: Vegetables.

PSYCHOTRIA EMINIANA (Kuntze) E.M.A.Petit

Protologue Bull. Jard. Bot. Brux. 34: 48 (1964).

Family Rubiaceae

Synonyms *Uragoga eminiana* Kuntze (1891), *Grumilea ungoniensis* K.Schum. & K.Krause (1907), *Grumilea stolzii* K.Krause (1920).

Origin and geographic distribution *Psychotria eminiana* is widespread in tropical Africa; it has been found from northern Nigeria, Central African Republic and Sudan south to Malawi, Zambia, Angola and Mozambique.

Uses In Malawi the leaves are cooked with ashes to prepare a slimy vegetable called 'thelele', which is particularly liked by older people. In DR Congo *Psychotria eminiana* is used medicinally against intestinal diseases and worms. In eastern Africa the rhizomes are used to treat snakebites; fresh rhizomes are chewed and the juice swallowed, or they may be pounded and the infusion used both orally and externally on the wound.

Properties No properties of *Psychotria eminiana* are known, but in general *Psychotria* species are rich in alkaloids. Best known is ipecac (*Psychotria ipecacuanha* (Brot.) Stokes), native to South and Central America but widely cultivated also elsewhere, of which the rhizomes contain a series of terpenoid tetrahydroisoquinoline type alkaloids such as emetine, cephaeline and psychotrine. The dried rhizome has long been an important medicine as an emetic, expectorant and to treat amoebic dysentery. In small doses the drug is a stimulant, increasing appetite and facilitating digestion.

Botany Subshrub to small tree up to 3.5 m tall, with woody or herbaceous, sparsely branched, glabrous to pubescent stems arising from a woody rhizome. Leaves opposite, simple; stipules triangular, up to 1 cm long, deciduous; petiole up to 3 cm long; blade ovate, oblong, obovate, elliptical or round, 3–25 cm × 2–13 cm, cuneate to rounded at base, apex emarginate to acuminate, margins entire, glabrous to pubescent, with domatia. Inflorescence a trichotomous to many-branched complex of many-flowered panicles; peduncle up to 13 cm long. Flowers bisexual, usually 5-merous, heterostylous, subsessile; calyx tubular with unequal triangular lobes less than 2 mm long; corolla tubular with tube up to 5 mm long and lobes 2.5 mm × 1 mm, yellowish; stamens inserted at middle of corolla tube; ovary inferior, 2-celled, style slender, stigma 2-lobed. Fruit a

globose 2-lobed drupe, 5–7 mm × 7–10 mm, red, glabrous to pubescent, containing 2 pyrenes c. 5 mm in diameter. Seeds subglobose, c. 4.5 mm in diameter, dark brown, ventral face flat.

Psychotria is a large pantropical genus of about 500 species, with over 200 species present in tropical Africa. *Psychotria eminiana* is rather variable and several varieties have been described. Most of the habit variation seems to be due to differences in burning frequency and damage. Plants that are protected for some years become much woodier than other ones.

In Cameroon the boiled leaves of *Psychotria leptophylla* Hiern are said to be used as a vegetable; this species is also found in Nigeria, the island Bioco (Equatorial Guinea) and DR Congo.

Ecology *Psychotria eminiana* occurs in deciduous thicket, *Brachystegia* woodland and derived open bushland, usually on dry burnt ground or stony hills but sometimes riverine, at 500–1650 m altitude.

Management *Psychotria eminiana* is only collected from the wild and not cultivated.

Genetic resources and breeding *Psychotria eminiana* is rather widespread and not in danger of genetic erosion.

Prospects *Psychotria eminiana* will remain a minor vegetable, locally important in the dry season when other vegetables are scarce. Its nutritional and medicinal properties should be investigated.

Major references Petit, E., 1964; Verdcourt, B., 1976; Verdcourt, B., 1989; Williamson, J., 1955.

Other references Anderson, L., 2002; Burkill, H.M., 1997; Kokwaro, J.O., 1993; Ong, H.C. & Brotonogoro, S., 2001; Petit, E., 1966.

Authors P.C.M. Jansen

PTERIDIUM AQUILINUM (L.) Kuhn

Protologue Cryptogamae vasculares. In: Decken, Reisen in Ost-Afrika 3(3): 11 (1879).

Family Dennstaedtiaceae

Chromosome number $2n = 52$, 104, 208

Synonyms *Pteris aquilina* L. (1753), *Pteris esculenta* G.Forst. (1786), *Pteris lanuginosa* Bory ex Willd. (1810), *Pteridium esculentum* (G.Forst.) Nakai (1825).

Vernacular names Bracken, brackenfern, eagle fern (En). Fougère-aigle, fougère grand-aigle, fougère des savanes (Fr). Feto ordinário, feto dos montes (Po). Mjimbi (Sw).

Origin and geographic distribution *Pteridium aquilinum* is a cosmopolite and especially common in temperate zones. It is present on all continents, including Antarctica. It is one of the most widespread plant species of the world. In Africa it ranges from the Mediterranean to the Cape.

Uses *Pteridium aquilinum* is widely used as a cooked vegetable. In the area around Bafoussam (Cameroon) it is reported to be consumed on a regular basis together with plants such as *Vernonia amygdalina* Delile and *Triumfetta rhomboidea* Jacq. In Gabon the young still enrolled fronds (croziers, fiddleheads) are reported to be edible. Several tribes in Angola eat the leaves. In Europe a number of accidents have happened with animals eating the leaves. Still, several sources mention its use as a vegetable in many countries, sometimes on a large scale. To render them edible, the croziers are soaked in water containing wood ashes for 24–36 hours to remove the free tannic acid. Up to the present the croziers are popular in Japan, where they are boiled, dried and stored for use in winter. Canned croziers are sold in Japan as 'warabi' or 'zenmai'.

In Madagascar and the Canary Islands the rhizome is reported to be edible, in France they were used as feed for pigs. The rhizomes produce starch, which was used extensively by Canadian Indians in the past. In Japan, the starch is used to make confections.

The leaves are used as straw for cattle and as bedding. The leaves are also used to filter oil and palm wine. Dried powder of croziers is applied to old wounds. In Côte d'Ivoire the pulp of cooked croziers is used as enema to overcome sterility in women. The rhizome together with the rhizome of ginger (*Zingiber officinale* L.) is pounded and the juice is drunk as an aphrodisiac. As component of a mixture with 7 other ingredients it is used to calm the mentally disabled.

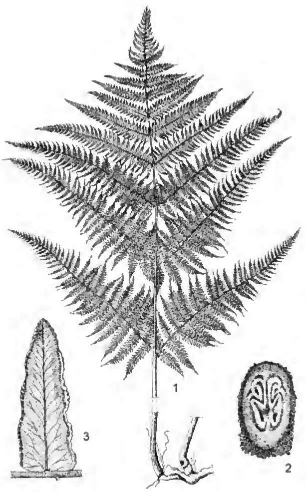
In China, water in which the leaves have been soaked is applied as a pesticide. The ash, having a high potash content, was formerly used extensively in Europe for glass and soap production. Bracken ash was particularly useful for making clear colourless glass. Wettened bracken ash was sold in balls to wash clothes and to bleach linen.

Properties The whole plant of *Pteridium aquilinum* contains poisonous and antinutritional compounds. The compounds isolated include sesquiterpenoids (ptaquiloside and related substances, in general called pterosins,

having insecticidal and carcinogenic activity), ecdysone (terpenoid compound, identical to the moulting hormone of insects), cyanogenic glycosides, tannins and phenolic acids. All these constituents may have some activity as a feeding deterrent. Shikimic acid has been found in all parts of bracken, especially in the rhizome. It has carcinogenic activity and may explain the occurrence of a fatal haemorrhagic syndrome in cattle and stomach cancer in humans after eating bracken foliage regularly. Bracken also contains an enzyme which destroys vitamin B_1, resulting in vitamin B_1 avitaminosis which causes brain damage in horses and other non-ruminants and acute enzootic haematuria ('redwater disease') in cattle. The occurrence and concentrations of the various chemical constituents vary with the subspecies and varieties. The rhizomes appear to be about five times as toxic as the leaves. It is hard to detect and diagnose poisoning because of the delayed toxicity. Symptoms and death have developed as long as eight weeks after animals had ceased to eat the plants. The health hazard for humans is reported to be greatest for young children.

Botany Terrestrial fern, with up to 2.5 m tall, finely divided leaves; rhizome long, creeping deep in the soil, repeatedly branched, covered with fine, pale brown hairs. Leaves appearing on short rhizome branches, never very close together; petiole thick, up to more than 1 m long, pale, in cross-section showing a horseshoe pattern of vascular bundles; lamina large, in outline ovate-triangular, up to 2 m × 1 m, 2–4-pinnate; all axes grooved on upper surface and often hairy; basal pair of pinnae usually subopposite, up to 70 cm × 40 cm, upper pinnae and pinnules gradually reduced and confluent; ultimate divisions pinnately compound or lobed, often with a long, entire, apical portion; segments oblong, obtuse, adnate, often with winged expansions at base, often interspersed with smaller and short lobes, margins entire, always revolute. Sori submarginal, linear, mostly continuous on marginal vein connecting the lateral vein ends; sporangia borne between the outer indusium consisting of the reflexed segment margin and the thin inner indusium. Spores trilete, tetrahedral-globose, 23–35 μm in diameter, irregularly granulate.

Pteridium aquilinum is a very variable species. Subsp. *aquilinum* is most common in Africa. Another subspecies, subsp. *centrali-africanum* Hieron. (synonym: *Pteridium centrali-africanum* (Hieron.) Alston), often regarded as a separate species, occurs from Gabon to Mozambique.



Pteridium aquilinum – 1, plant habit; 2, cross section rhizome; 3, fertile part leaf segment. Source: PROSEA

Ecology *Pteridium aquilinum* grows along forest margins and the edges of thickets in savannas, where it may form dense populations of almost pure stands, and is often regarded a weed. It prefers altitudes of 750–2350 m.

Management Because of its ability to form dense man-high populations, bracken may hamper the development of young trees. It invades new areas at a rapid pace; young plants develop up to 45 fronds (leaves) in the second year and about 140 in the third. Once established the underground rhizomes, which may be situated as deep as 60 cm below soil surface, keep producing new fronds for many years. Moreover, the plant produces allelopathic compounds. In South-East Asia it can be a weed in tea and other plantation crops. In Scotland, methyl (4-aminobenzenesulphonyl) carbamate, sprayed on the foliage is an effective means of control. *Corticium anceps*, *Fusarium* spp. and *Septoria aquilina* are parasitic fungi found on

Pteridium aquilinum, and may form potential sources of biological control. Bracken has almost no serious insect enemies because it contains ecdysone which interferes with the moulting processes of insects.
Reproduction of *Pteridium aquilinum* is mainly by vegetative means, even though up to 300 million spores may be produced by a single leaf. When mature, spores are mechanically ejected 1–2 cm in the air during dry weather, dispersed by wind and often deposited with the first rain thereafter. The spores germinate without any period of dormancy. Young plants may be found after 6–7 weeks.
Statistics on production and trade of *Pteridium aquilinum* are scarce. In 1970 over 300 t bracken croziers were consumed in Tokyo alone, and in the whole of Japan annual consumption may have reached several thousand t. Only a few statistical data are available on its yield. It has been estimated that the annual rhizome production may amount to 17 t/ha. It has been calculated that 50 t of dried bracken are required to produce one t of potash.

Genetic resources and breeding Being a cosmopolite *Pteridium aquilinum* is not in danger of genetic erosion. Germplasm collections and breeding programmes are not known to exist.

Prospects The importance of bracken is mainly local and often only historical. The fact that all plant parts are suspected or confirmed poisonous limits their suitability for human consumption. In Africa the use of *Pteridium aquilinum* as food must therefore be discouraged or closely monitored, and health authorities should warn the local populations of its dangers. Most other uses are trivial, and many alternatives exist. It is not likely that the plant will increase in importance, certainly not in Africa, although its use as a natural pesticide seems to provide an as yet unknown opportunity for Africa. The medicinal and pesticidal qualities need further investigation.

Major references Haerdi, F., 1964; Kerharo, J. & Bouquet, A., 1950; Koagne, H., 1999; Raponda-Walker, A. & Sillans, R., 1961; Titien Ngatinem Praptosuwiryo & Jansen, P.C.M., 2003.

Other references Alston, A.H.G., 1959; Cody, W.J. & Crompton, C.W., 1975; d'Oliveira Fejião, R., 1960; Everist, S.L., 1974; Kingsbury, J.M., 1964; Nwosu, M.O., 2002; Schelpe, E.A.C.L.E., 1970c; Tardieu-Blot, M.L., 1964c; Tryon, R.M. & Tryon, A.F., 1982.

Sources of illustration Titien Ngatinem Praptosuwiryo & Jansen, P.C.M., 2003.

Authors W.J. van der Burg
Based on PROSEA 15(2): Cryptogams: Ferns and fern allies.

PTEROCARPUS MILDBRAEDII Harms

Protologue Notizbl. Bot. Gart. Berlin 8: 152 (1922).

Family Papilionaceae (Leguminosae - Papilionoideae, Fabaceae)

Vernacular names Padouk blanc (Fr). Mkula (Sw).

Origin and geographic distribution *Pterocarpus mildbraedii* is found in Sierra Leone, Liberia, Côte d'Ivoire, Ghana, Benin, Nigeria, Cameroon, Equatorial Guinea, Gabon and the Usambara and Udzungwe Mountains (Tanzania). Records for DR Congo are based on misidentification.

Uses The leaves of *Pterocarpus mildbraedii* are used as a cooked vegetable in Nigeria. In Ghana the trees have been planted or retained in cocoa plantations to provide shade. *Pterocarpus mildbraedii* is rarely exploited for its timber, e.g. in Tanzania, and the wood is used to make mortars.

Properties The leaves of *Pterocarpus mildbraedii* contain per 100 g edible portion: water 85 g, energy 237 kJ (57 kcal), protein 3.8 g, fat 0.8 g, carbohydrate 8.2 g, crude fibre 1.13 g, Ca 72 mg, Mg 28 mg, Fe 4.7 mg and Zn 3.1 mg (Akpanyung, E.O., Udoh, A.P. & Akpan, E.J., 1995). Hydrogen cyanide and oxalate levels are high but not such that they pose a health danger for consumers. An ethanolic extract proved toxic to rats only after intraperitoneal administration. The wood is whitish and soft, and of little commercial value.

Botany Medium-sized to large tree up to 35 m tall, with smooth, grey or pale brown bark, exuding red gum when cut, and small, rounded crown. Leaves alternate, imparipinnate, up to 35 cm long; stipules lanceolate, up to 1 cm long, caducous; leaflets (5–)7–15, alternate, elliptical-oblong to ovate, 6–14 cm × 3–7 cm, base rounded to cuneate, apex abruptly acuminate. Inflorescence a raceme or little-branched panicle 5–15 cm long. Flowers bisexual, papilionaceous, 5-merous; calyx 5–8 mm long, densely covered with short hairs on the lobes inside and near lobe margins outside; corolla golden-yellow, 1–1.5 cm long. Fruit an obovate-orbicular pod 10–12 cm long, with very broad membranous wing, style base lateral, 1(–2)-seeded.

Pterocarpus comprises about 60 species, 20 of them in Africa. Several Asian and African species are commercial timbers. *Pterocarpus santanalioides* DC., *Pterocarpus soyauxii* Taub. and *Pterocarpus osun* Craib, all primarily used for timber, have leaves that are used as vegetable as well.

The two disjunct populations of *Pterocarpus mildbraedii* in West-Central Africa and East Africa are sometimes considered as subspecies: subsp. *mildbraedii* and subsp. *usambarensis* (Verdc.) Polhill, respectively. They differ in the size of bracts and flowers.

Pterocarpus mildbraedii grows fast and coppices well. Its root system is superficial: most roots are in the top 30 cm of the soil. It has an intermittent pattern of leaf flushes. Flushes appear in the dry season when other leafy vegetables are scarce.

Ecology *Pterocarpus mildbraedii* occurs in lowland rainforest, dry evergreen forest and riverine forest, up to 1250 m altitude. In Tanzania it is restricted to altitudes of 300–600 m. It is tolerant of acid soil.

Management *Pterocarpus mildbraedii* leaves are collected from the wild, but frequently marketed. Attempts to domesticate it are being made. Propagation can be done by seed, budding or cuttings.

Genetic resources and breeding In West and Central Africa *Pterocarpus mildbraedii* is widespread, although in some countries recorded as rare (e.g. in Ghana), and does not seem to be liable to genetic erosion. However, the populations in Tanzania are of limited extent and vulnerable.

Prospects *Pterocarpus mildbraedii* is a nutritious vegetable but despite this is only exploited as such in southern Nigeria. A better understanding of the variation in the species might help in the process of domestication. It is being tested in agroforestry systems.

Major references Gillett, J.B., Polhill, R.M., Verdcourt, B., Schubert, B.G., Milne-Redhead, E., & Brummitt, R.K., 1971; Okafor, J.C., 1991; Okigbo, B.N., 1977; Rojo, J.P., 1972.

Other references Ajibesin, K.K., Bala, D.N., Ekpo, B.A.J. & Adesanya, S.A., 2002; Akinnifesi, F.K., Kang, B.T. & Ladipo, D.O., 1998; Akpanyung, E.O., Udoh, A.P. & Akpan, E.J., 1995; Burkill, H.M., 1995; Normand, D. & Paquis, J., 1976; Roe, D., Mulliken, T., Milledge, S., Mremi, J., Mosha, S. & Grieg-Gran, M., 2002; Rojo, J.P. & Alonzo, D.S., 1993.

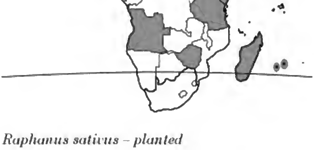
Authors C.H. Bosch

RAPHANUS SATIVUS L.

Protologue Sp. pl. 2: 669 (1753).
Family Brassicaceae (Cruciferae)
Chromosome number $2n = 18$

Vernacular names Radish, Chinese radish, Japanese radish, mooli, daikon (En). Radis, daïkon, navet chinois (Fr). Rábano, rábão, rabanete chinês (Po). Mfijili (Sw).

Origin and geographic distribution *Raphanus raphanistrum* L. is the most likely ancestor of the polymorphic *Raphanus sativus*. The area of maximum diversity of radish lies between the eastern Mediterranean and the Caspian Sea, which is probably the original gene centre for this species. Radish was cultivated already in ancient times in the Mediterranean, from where it spread to China in about 500 BC and to Japan in about 700 AD. The variability diminishes gradually from the Caspian Sea to China, and even more towards Japan. It is also a crop that has been cultivated since ancient times in the oases of the Sahara and in Mali. Radish can now be found as a cultigen throughout the world in many different forms, from small leafy annuals to biennials with large fleshy roots. The cultivars with relatively small roots (small radish) are most important in temperate climates of the world and only of limited importance in Africa, mostly in francophone countries amongst people originating from Europe. Larger-rooted cultivars (like Chinese radish) are most important in East and South-East Asia. In East Africa and elsewhere in the cooler parts of the African continent, large, white radishes are known under the Swahili/Arabic name 'fijili' and the Hindi name 'mooli' and these are becoming increasing-



Raphanus sativus – planted

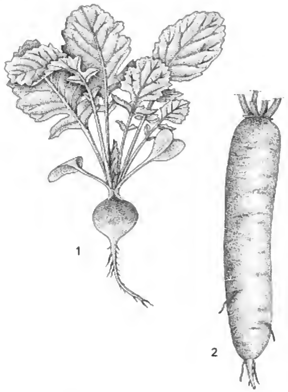
ly popular. In francophone West Africa Chinese radish is becoming popular, replacing the traditionally grown vegetable turnip (*Brassica rapa* L.), which is very susceptible to anthracnose. Large radishes with a dark grey-brown surface are occasionally seen in southern Africa and are sold under the name 'black Spanish radishes'; they are more commonly grown in Europe under the name 'black radish'.
The so-called 'rat-tailed radish', grown for its green or purple 20–60 cm long pods, is rather important in India and eastern Asia, but only of minor importance for Asian immigrants in East Africa, where it is called 'mogri'. Finally, the so-called 'leaf radish' is gaining importance in Europe and South Africa as forage and green manure but is not known to be cultivated in tropical Africa.
In summary, radish occurs scattered throughout Africa; it has been recorded for over a dozen countries, from Mali to Eritrea, and southwards to South Africa and the Indian Ocean islands, but is probably cultivated in many more. It is commonly recorded as an escape from cultivation.

Uses Radish is grown mainly for its thickened fleshy root. Small radishes are pungent and used as appetizer when eaten fresh and for adding colour to dishes. Oriental radish (to which Chinese radish, Japanese radish and mooli belong) is crisp with a mild flavour. The roots are thinly peeled, sliced or diced and put into soups and sauces or cooked with meat. They can be preserved in salt. Oriental radish can also be eaten fresh, mixed with other vegetables such as tomato. Also the leaves are eaten as salad or spinach. Seedlings known as radish sprouts are used as greens for appetizers in the same way as cress (*Lepidium sativum* L.) or cooked as spinach. Rat-tailed radish is grown for the immature crisp, fleshy fruits, consumed raw, cooked or pickled, but the roots are not edible. Leaf radish is mainly grown as green manure and forage in central and western Europe and is also grown as fodder for cattle in South Africa. There are forms of radish that are used as an oil-seed crop but these are not known to be grown in Africa. In traditional medicine, radish is used to treat hepatic disorders, bronchitis and coughs.

Production and international trade World production of radish roots is estimated at 7 million t per year, about 2% of the total world production of vegetables. In Japan, Korea and Taiwan, but also in Yemen, radish ranks high in importance. No production data are known from tropical Africa but its significance is minor when compared with Asia or Europe.

Properties The composition of the raw root of white radish (mooli) per 100 g edible portion (87% of the product as purchased) is: water 93.0 g, energy 64 kJ (15 kcal), protein 0.8 g, fat 0.1 g, carbohydrate 2.9 g, fibre 1.5 g, Ca 30 mg, P 25 mg, Fe 0.4 mg, carotene 0 µg, thiamin 0.03 mg, riboflavin 0.02 mg, niacin 0.5 mg, ascorbic acid 24 mg. The composition of the raw leaves per 100 g edible portion (90%) is: water 89.7 g, energy 137 kJ (33 kcal), protein 3.5 g, fat 0.5 g, carbohydrate 3.5 g, Ca 200 mg, P 44 mg, Fe 3.8 mg, carotene 3670 µg, thiamin 0.13 mg, riboflavin 0.35 mg, niacin 0.8 mg, ascorbic acid 63 mg (Holland, B., Unwin, I.D. & Buss, D.H., 1991).
The pungency of radishes depends on the content of isothiocyanates, which varies with cultivar and environmental conditions. The main compound is 4-methylthio-3-trans-butenyl isothiocyanate. Glucosinolates, which are the precursors of isothiocyanates, are also present. These compounds have long been known for their fungicidal, bactericidal, nematicidal and allelopathic properties, and have recently attracted attention because of their chemoprotective attributes against cancer.

Description Erect, annual herb up to 100 cm tall; upper part of taproot and hypocotyl swollen, tuberous, globular, cylindrical or tapering, very variable in size (up to 100 cm long), form and weight (from a few g to 2.5(–20) kg), red to white, sometimes grey to black, flesh white, sometimes red. Leaves alternate, glabrous to sparingly hispid, lower leaves in a radical rosette; stipules absent; petiole 3–5.5 cm long; blade oblong, oblong-ovate to lyrate-pinnatifid, 3–5-jugate with a round or ovate terminal lobe, 5–30 cm long; higher leaves much smaller, shortly petioled, lanceolate-spatulate, more or less dentate. Inflorescence a terminal, erect, long, many-flowered raceme. Flowers bisexual, 4-merous, c. 1.5 cm in diameter, fragrant, white to lilac; pedicel up to 2.5 cm long; sepals free, oblong-linear, 6–10 mm long; petals free, spatulate, clawed, 1–2 cm long; stamens 6, 4 long and 2 short; ovary superior, style 3–4 mm long. Fruit cylindrical, up to 10(–60) cm × 1.5 cm, consisting of 2(–several) superposed joints, lower joint very short and seedless, upper one much larger, terete, spongy and divided into 2–12 one-seeded compartments, indehiscent, with a long, seedless beak. Seeds ovoid-globose, c. 3 mm in diameter, yellowish.



Raphanus sativus – 1, habit (small radish); 2, root (mooli).
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information Radish is derived from the variable wild radish *Raphanus raphanistrum* L., which is frequently found as a weed in cooler parts of Africa and may act as a host for a range of pests and diseases affecting cruciferous crops. *Raphanus* is closely related to *Brassica* and it has been hypothesized that it was derived from hybridization between the *Brassica rapa* L. / *Brassica oleracea* L. complex and *Brassica nigra* (L.) Koch. This hypothesis is also supported by results of DNA sequencing. The taxonomy of *Raphanus sativus* is still confusing and further research is needed.
Some cultivars adapted to the tropics and used in Africa are the small radishes 'Cherry Belle' or 'Radis Cerise' (red and round), 'Sparkler' (round with a red top and white base), 'French Breakfast' or 'Radis 18 Jours' (similarly red/white but more cylindrical), 'White Icicle' (long and white, with a mild taste), and the mooli types 'Red Bombay', 'White Bombay', 'Bombay Long White', 'Ural' and 'Himalaya'.

Growth and development The edible part consists of the thickened hypocotyl (small radish) or of the thickened hypocotyl and upper part of the taproot (Chinese radish). Growing time depends on cultivar and desired product. Small radishes can be harvested 3–5 weeks after sowing whereas Chinese radishes usually take about 8–10 weeks from sowing till harvesting. At first the leaves grow in a rosette, but towards anthesis the stem elongates and branches. Flowers are cross-pollinated by insects.

Ecology Radish is a vegetable of temperate regions, performing best in the tropics at higher latitudes (>10°) during the cool season and in highlands above 1000 m. Chinese radish or mooli tolerates higher temperatures than the Japanese or European types and produces well at lower elevations in East Africa. Under short daylength conditions, the roots are well shaped and tops small. Under long days (>15 hours) the roots can be misshapen, the tops elongate and pre-mature bolting may occur. Radish normally needs low temperature and a long daylength for bolting, but most radish types flower, although rather poorly, after reaching the edible size. Temperate types need at least 20 days below 15°C and a daylength of >16 hours for good seed setting, but for tropical cultivars of Chinese radish and mooli, bolting requirements are met at higher temperatures and short daylengths. White-fleshed cultivars flower more easily under short days at low elevations than red-fleshed cultivars, which require long days or elevations above 1000 m. Radish requires light, well-drained, deep soils with a pH of 6.0–6.5.

Propagation and planting The 1000-seed weight is about 10 g. Seed rates are 10–15 kg/ha for large radishes and 30–40 kg/ha for small ones. Seed is sown directly on prepared beds in drills. Radish seeds take about 4 days to emerge at 20–30°C. Mooli types require a rather wide spacing of 30 cm between rows and 15–25 cm between plants, depending on the cultivar. Small radish requires a narrow spacing of 10–25 cm between rows and is thinned to 2–4 cm between plants in the row. For small areas, seed is often broadcast.

Management In commercial cultivation, radish is normally grown as a sole crop, but intercropping with lettuce is also practised in many areas. Adequate supplies of organic material, e.g. 20 t/ha, and a basal dressing of NPK followed by surface dressings of an N-fertilizer at regular intervals until the roots are mature, are recommended. A crop of 20 t/ha needs at least 250 kg N, 40 kg P and 350 kg K per ha. Too high levels of NPK increase the risk of

pithiness unless moisture levels are kept high. To remain mild, tender and visually attractive, radish must grow rapidly with plenty of moisture. If growth is restrained, the roots become too pungent, tough and pithy. Light shading improves root quality during hot, dry weather. In heavy soils roots often become misshapen.

Diseases and pests Common leaf diseases are *Cercospora* leaf spot (*Cercospora brassicicola*) and downy mildew (*Peronospora parasitica*). Downy mildew also attacks the tuberized part of the hypocotyl with black corky spots. It does not occur in the lowlands at day and night temperatures above 23°C and 12°C, respectively. Incorporating formulations of the systemic benzenoid fungicide metalaxyl with the seed at the rate of 4 g/kg seed just before sowing reduces field infestation of downy mildew. Serious root diseases in temperate areas are black rot (*Aphanomyces raphani*) and *Fusarium* yellows (*Fusarium oxysporum* f. *raphani*). Club root (*Plasmodiophora*) is increasingly a problem in tropical highlands in East and southern Africa on soils with a low pH. Important pests are flea beetles (*Phyllotreta* spp.), which attack young seedlings, aphids (*Aphis gossypii*, *Lipaphis erysimi*), which cause leaf curl and transmits cauliflower chlorotic ring virus, and mustard sawfly (*Athalia proxima*), which feeds on the leaves. Root-knot nematodes (*Meloidogyne* spp.) are sometimes a problem, but can be controlled by crop rotation and heavy organic manure application.

Harvesting Radish must be harvested when fully developed but before the roots become over-mature and pithy or tough. It may be harvested with or without leaf tops. Small radishes can be harvested mechanically, uprooted, trimmed and bunched in one operation, but small scale gardeners harvest manually. Leaves are harvested when required.

Yield Approximately 7–10 t/ha of fresh radish can be achieved for early-maturing cultivars of small radish. Yields of mooli types vary between 15–20 t/ha and more when roots are left in the field for a longer time.

Handling after harvest Radishes are washed thoroughly to remove soil and to maintain a fresh appearance, followed by grading and packaging. Small radishes are usually sold with tops and these are tied in bunches. Their leaves should be turgid, green, and free from blemishes. The larger Chinese radish types and the Spanish black types are sold by weight or individually, especially for the larger roots. Fruits of rat-tailed radishes are offered loose but these are only occasionally found in markets, e.g. in Nairobi. Rapid cooling, using crushed ice or cold water to remove heat, helps retain good quality. At high relative humidity and a temperature of 0°C, radish can be stored for 28 days, but at 7°C the storage life is less than 7 days. Roots with leaves attached have half the storage life of topped roots, which is why some supermarkets now offer radishes without leaves.

Genetic resources Germplasm collections are maintained by NIAR (Tsukuba, Japan), IPB (Los Baños, Philippines), Department of Agriculture (Bangkok, Thailand), USDA (Fort Collins, United States), and the Crucifer Genetics Cooperatives at the University of Wisconsin (Madison, United States). No local cultivars are known in tropical Africa.

Breeding Although radish flowers and sets seed easily in most African countries where it is grown, virtually all seed is imported. No special breeding for adaptation to African conditions has been reported. For economic reasons radish seed is normally produced in more temperate climates and imported in tropical Africa. In seed production, open-pollinated cultivars may give a seed yield of 800 kg/ha; an isolation distance of 1000 m is required. Self-incompatibility and male sterility are available for the production of F_1 hybrid seed.

Prospects Radish, especially the Chinese and mooli types, can successfully be cultivated in many places in tropical Africa. Although at the moment of relatively little importance, radish consumption will probably steadily increase. Breeding of heat-tolerant cultivars for cultivation in African lowland areas is recommended.

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Other references Burkill, H.M., 1985; Fahey, J.W., Zalcmann, A.T. & Talalay, P., 2001; FAO, 1988; Pistrick, K., 1987; Popovic, M., Lukic, V., Jakovljevic, V. & Mikov, M., 1993; Yang, Y.W., Tai, P.Y., Chen, Y. & Li, W.H., 2002.

Sources of illustration Vaughan, J.G. & Geissler, C.A., 1997.

Authors R.R. Schippers

Based on PROSEA 8: Vegetables.

RAVENEA ROBUSTIOR Jum. & H.Perrier

Protologue Ann. Inst. Bot.-Géol. Colon. Marseille sér. 3, 1(1): 49, t. 27 (1913).

Family Arecaceae (Palmae)

Origin and geographic distribution *Ravenea robustior* is endemic to Madagascar.

Uses The young terminal bud (palm heart) of *Ravenea robustior* is eaten as a vegetable, but some consider it too bitter. The palms are said to be large enough to feed a whole village. It is reported that the 'pith', the central soft part of the trunk, can be eaten as well. Young leaves are used for making brooms, and fully developed leaves are used for thatching. The outer wood is used for making floorboards, tables, house walls; it is said to be termite resistant. In former days salt was extracted from the ash of the trunk pith. *Ravenea robustior* is also a specialty ornamental.

Properties There is no specific information on the composition of the palm heart of *Ravenea robustior*, but probably it is comparable to that of palm heart in general which contains per 100 g raw edible portion: water 69.5 g, energy 481 kJ (115 kcal), protein 2.7 g, fat 0.2 g, carbohydrate 25.6 g, fibre 1.5 g, Ca 18 mg, Mg 10 mg, P 140 mg, Fe 1.7 mg, vitamin A 68 IU, thiamin 0.05 mg, riboflavin 0.18 mg, niacin 0.9 mg, folate 24 mg, ascorbic acid 8 mg (USDA, 2002).
The wood is extremely hard on the outside, due to many black fibres. The heartwood is soft and white.

Botany Large palm with trunk (6–)12–30 m tall, 20–60 cm in diameter at breast height, base bulbous, 50–100 cm across. Leaves 11–25 in crown, pinnately compound; sheath grading smoothly into the petiole; petiole up to 135 cm long, channelled with sharp edges, thickly grey-brown tomentose; rachis up to 4 m long; leaflets (40–)50–105 on each side of the rachis, stiff, dark green, median leaflets 60–125 cm × 5.5–7.5 cm at intervals of 2–5 cm, top pair often connate for up to 5 cm. Inflorescence unisexual, solitary; male inflorescence branching to 2 orders, peduncle 50–60 cm long, bracts 6, rachis 85–130 cm long, yellowish, with 60–140 branches up to 50 cm long, straw-yellow; female inflorescence spreading or pendulous in fruit, branched to 1 order, peduncle 45–100 cm long, bracts 6, rachis 55–80 cm long, with 45–100 branches up to 80 cm long, waxy green to orange when in fruit. Fruit an orange, obovoid to ovoid-globose drupe 1–2 cm × 1–1.5 cm, 1(–3)-seeded. Seed 9–16 mm × 6–13 mm, red-brown, hard.
In Madagascar the palm heart of three other *Ravenea* species is eaten. *Ravenea dransfieldii* Beentje has a bitter palm heart, but it is eaten although some believe it to be poisonous; the leaf fibres are used in hat making. *Ravenea sambiranensis* Jum. & H.Perrier has a slightly bitter palm heart, which is eaten cooked with manioc; the fruits are also consumed and the outer wood is suitable for making planks for floorboards. The palm heart of *Ravenea albicans* (Jum.) Beentje is also eaten.

Ecology *Ravenea robustior* grows in moist forest in valley bottoms, on medium or steep slopes, near water or near hill crests, from sea-level up to 1000(–2000) m altitude. It is locally common.

Management *Ravenea robustior* is reported as being cultivated in Madagascar but no further details are known. Seeds, collected from the wild, are offered on the international market for ornamental purposes. The seeds do not seem to be recalcitrant. There are about 1700 seeds per kg and germination takes 1–3 months.

Genetic resources and breeding The continued cutting for palm heart and construction wood might endanger *Ravenea robustior* in the near future, although some protected populations exist in nature reserves. *Ravenea albicans* is ranked 'endangered' with only two known locations; *Ravenea dransfieldii* and *Ravenea sambiranensis* are both ranked 'vulnerable'.

Prospects *Ravenea robustior* is an important source of food (with high nutritional value) and other useful plant parts for the local population. In view of the increasing scarcity of this palm and the long life cycle, it is important to extend planting activities. Seed should be collected from various provenances for safekeeping of the genetic diversity.

Major references Beentje, H.J., 1994a; Beentje, H.J., 1995; Dransfield, J. & Beentje, H.J., 1995; Jumelle, H., 1927; Jumelle, H., 1945.

Other references Ferguson, I.K., Dransfield, J. & Flawn, I., 1988; USDA, 2002a.

Authors W.J. van der Burg

RHEUM ×HYBRIDUM Murray

Protologue Novi Comment. Regiae Sci. Gott. 2(5): 50, t. 11 (1775).

Family Polygonaceae

Chromosome number 2n = 44

Synonyms *Rheum ×cultorum* Thorsrud & Reisaeter (1948), *Rheum rhabarbarum* auct. non L.

Vernacular names Rhubarb (En). Rhu-

barbe (Fr). Ruibarbo, rabárbaro (Po).

Origin and geographic distribution Cultivated rhubarb is of unclear hybrid origin, one of the parents probably being *Rheum rhabarbarum* L. from Mongolia and neighbouring territories. The medicinal use of several *Rheum* species in China dates from 4500 years ago, whereas the culinary use of rhubarb in Europe dates from the 18th century only, but is older in Asia. Rhubarb is cultivated as a vegetable in many temperate regions, but can be found occasionally in tropical highlands, e.g. in East and southern Africa.

Uses The fleshy leaf stalks are chopped and stewed with sugar. The produce is eaten either as a side dish with a staple food and meat, served as a sweet dessert, used in pies or made into jam. Some users add lime to temper the acidity, but then the taste also fades. Wild *Rheum* species, but also rhubarb, are used in traditional medicine in Asia for lowering blood pressure and cholesterol, inhibiting progression of diabetic nephropathy, and curing cerebral injuries.

Production and international trade Although rhubarb is a fairly important vegetable in temperate areas, there are few statistical data on production and trade. In tropical Africa it is grown on a small scale, mainly for European clientele, mostly in Zimbabwe.

Properties The nutritional composition of raw rhubarb per 100 g edible portion is: water 93.6 g, energy 88 kJ (21 kcal), protein 0.9 g, fat 0.2 g, carbohydrate 4.5 g, fibre 1.8 g, Ca 86 mg, Mg 12 mg, P 14 mg, Fe 0.2 mg, Zn 0.1 mg, vitamin A 102 IU, thiamin 0.02 mg, riboflavin 0.03 mg, niacin 0.30 mg, folate 7 µg, ascorbic acid 8 mg (USDA, 2002). The pleasantly acid taste is caused by the presence of malic, oxalic and citric acids and saturated and unsaturated C_6 aldehydes and acids. Rhubarb contains free oxalic acid. The oxalate content varies between cultivars and samples. In 71 rhubarb genotypes the mean content of water-soluble oxalate on a dry matter basis was 3.1% (1.6–6.0%), that of total oxalate 5.9% (3.2–9.2%); the mean content of malate was 21.0% (12.2–29.2%). If consumed in modest portions and not more than a few times per week, health hazards are unlikely. Anthocyanins in the juice of the leaf stalk are responsible for the red colour. A common antinutritional component in *Rheum* species is the mutagenous anthraquinone, but no evidence of mutagenicity has been detected in rhubarb leaf stalks. Anthraquinone concentrations are higher in the leaf blades and roots.

Rheum ×hybridum – 1, plant habit; 2, leaf stalk; 3, inflorescence branch; 4, flower; 5, fruit. Source: PROSEA

Description Robust, perennial, tufted herb up to 1.5 m tall, with a woody rhizome and fleshy roots. Leaves in a rosette, simple, large, alternate and gradually smaller on flowering stem; stipules united to form a large, whitish, membranous sheath; petiole up to 1 m long and often more than 2 cm in diameter, fleshy, on the upper side flat, on the underside obscurely grooved or rounded with sharp margins, green often tinged with red or pink; blade broadly ovate or cordate, 20–50 cm × 15–50 cm, base cordate, apex obtusely rounded, margins undulate or crispy and irregularly ciliate, palmately 3–7-veined, pubescent on the veins beneath. Inflorescence a large panicle, many-flowered. Flowers bisexual, small, greenish-white; tepals in 2 whorls of 3, free; stamens 9; ovary superior, 1-celled, styles 3. Fruit an ovoid nut c. 1 cm long, with 3 membranous wings.

Other botanical information *Rheum* comprises about 50 species; in Asia several wild species are used in the same way as rhubarb and are occasionally cultivated as a vegetable, but more often for medicinal uses. The name *Rheum ×hybridum* designates all commercially cultivated hybrid rhubarb, as the identity of the

parents is not known. Some well-known cultivars are 'Early Red', 'Prince Albert', 'Victoria', 'Linneus', 'Oregon Red Giant' and 'Crimson'.

Growth and development Rhubarb plants grow fast and in the tropics normally without dormancy. They stay vegetative and continuously produce new leaves. Harvesting should not be carried out during the first 6 months to enable plants to become well established and to build up reserves. Rhubarb can be harvested for many years, but needs a period of rest after each harvesting season. The plant clumps are divided and replanted in fresh soil about once every 5 years to prevent the development of a high proportion of small leaf stalks with low commercial value.

Ecology In temperate climates plants enter a dormancy period during winter, but in tropical conditions dormancy usually does not occur. Dormancy is induced by very short days (< 10 hours) rather than by low temperatures. Elongating daylength, combined with higher temperatures and irrigation after drought will break the dormancy. Rhubarb is well adapted to high rainfall conditions provided drainage is good. It cannot stand waterlogging. Cultivation in the tropics is mostly above 800 m altitude. The optimum temperature for growth is 10–25°C. Diurnal variations in temperature are beneficial for growth.

For flowering rhubarb requires a vernalization temperature below 6°C for several months. Consequently, rhubarb rarely flowers in the tropics. Most cultivars are sensitive to temperatures above 30°C, causing the production of spindly, weak leaf stalks and reducing the desired red colour. Soils should have a high content of organic material and nutrients for satisfactory yields. A moisture-retaining, but well-drained soil is preferable. Although rhubarb tolerates acid conditions, growth is optimal in the pH range 6.5–7.0.

Propagation and planting Rhubarb is propagated by division of the rhizome into pieces with at least one well-developed bud. A new planting should only be started from vigorous healthy mother plants. Rhizomes should preferably be divided and planted during the dormant phase, in temperate climates in late autumn, in the tropics at the beginning of the rainy season. Propagation from seed is only recommended for a few commercially available cultivars; in other cultivars the resulting plants are likely to be variable and high quality cannot be guaranteed.

Before planting the soil should be deeply cultivated. Planting material is placed in trenches or furrows about 30 cm deep, 75–100 cm apart, with 1.5–2 m between rows, partially filled with organic manure or compost, the buds just showing at the soil surface. Under favourable conditions plants may expand to 1.5 m in diameter. If necessary, drainage can be improved by planting on raised beds or ridges.

Management Rhubarb should be kept well watered and free from weeds, particularly while establishing. Flowering stems, which are rare in the tropics, should be removed as they weaken the plant. The mineral uptake is quite high and regular applications of NPK are required to stimulate growth.

Diseases and pests Rhubarb is susceptible to virus diseases, e.g. arabis mosaic virus (ArMV), turnip mosaic virus (TuMV) and strawberry latent ringspot virus (SRLSV), which cause gradual degeneration. It may act as permanent source of infection for other crops. In temperate areas, virus-free planting material is obtained by meristem culture. A main problem is root rot caused by soil fungi (*Pythium*, *Phytophthora*) or bacteria and worsened by impaired drainage. *Ramularia rhei* and *Cercospora* may attack the leaf blades causing leaf spot. In Zimbabwe chrysomelid leaf beetles (*Altica* sp.) and aphids (*Macrosiphum euphorbiae*, *Myzus persicae*) have been observed as pests. Rhubarb is moderately susceptible to root-knot nematodes (*Meloidogyne* spp.)

Harvesting Harvesting is done by pulling and twisting the leaf stalks upwards so that they separate cleanly from the rhizome. Adult plants can be harvested weekly or each time when sufficient new leaves have developed, leaving at least 4 leaves for photosynthesis and new production. Usually the tough old leaves and small young ones are left. After a harvest period of some months a rest period is recommended in order not to exhaust the plants.

Yield In temperate areas an annual yield of 1.5–3 kg of leaf stalks per plant is obtained, but in the tropics the plants usually have less vigour and yield less.

Handling after harvest After harvesting the leaves, the blades are removed and the basal sheath of the stalk may remain attached or be trimmed. The produce can be stored for up to 3 weeks at 0–2°C and >90% relative humidity.

Genetic resources A germplasm collection of *Rheum* species is maintained at the Nordic Gene Bank, Swedish University of Agricultural Sciences, Uppsala. Rhubarb found in Africa

usually results from old introductions and often has poor growth and small leaf stalks, possibly because of degeneration through virus infection.

Breeding Breeding is relatively easy as different species hybridize easily and promising selections can be propagated vegetatively. Seed companies have little interest in rhubarb, although several seed-propagated cultivars are available. Breeding criteria for cultivars adapted to the tropics are vigour, large leaf stalks free of strings, red colour, low acidity and oxalate content, and tolerance to high temperatures, drought and waterlogging.

Prospects In tropical Africa rhubarb is likely to remain of local importance only and there is no high priority for research or breeding. Adapted virus-free planting material should become available, or seed of adapted cultivars. The medicinal properties of rhubarb need more attention.

Major references Choudhury, B., 1967; Commonwealth Bureau of Horticulture and Plantation Crops, 1970; Huibers-Govaert, I.I.M., 1993; Rubatzky, V.E. & Yamaguchi, M., 1997; Tindall, H.D., 1968; USDA, 2002a.

Other references Dregus, M., Barta, J. & Engel, K.H., 2003; Hiller, L.K., Kossowski, M. & Kelly, W.C., 1974; Libert, B. & Englund, R., 1989; Marshall, D.E., 1988; Paneitz, A. & Westendorf, J., 2000; Rumpunen, K. & Henriksen, K., 1999; Wells, P.D. & Going, W.D., 1983.

Sources of illustration Huibers-Govaert, I.I.M., 1993.

Authors G.J.H. Grubben

Based on PROSEA 8: Vegetables.

RORIPPA MADAGASCARIENSIS (DC.) Hara

Protologue Journ. Jap. Bot. 30: 197 (1955).

Family Brassicaceae (Cruciferae)

Synonyms *Nasturtium humifusum* Guill. & Perr. (1831), *Rorippa humifusa* (Guill. & Perr.) Hiern (1896).

Vernacular names Watercress, African cress, Nigerian watercress (En). Cresson, cresson sauvage, cresson du Sénégal (Fr).

Origin and geographic distribution *Rorippa madagascariensis* occurs widespread but scattered in tropical Africa, particularly along the west coast from Senegal to northern Namibia, but also in Central (Central African Republic, DR Congo, Burundi), East (Uganda, Tanzania) and southern Africa (Zambia), and in Madagascar.

Uses *Rorippa madagascariensis* is collected from the wild and eaten raw as a salad in many countries, comparable with the cultivated watercress (*Nasturtium officinale* R.Br.). It imparts a peppery flavour. It can also be consumed cooked or in soups. It is a good forage for livestock. In Nigeria the leaves are considered to purify the blood.

Botany Annual herb with fine taproot, more or less glabrous, with very short stems. Leaves in a rosette, pinnatipartite, 3–11 cm × 2 cm, petiolate; segments in 4–6 pairs, orbicular to ovate, up to 1.5 cm long, margin crenate to dentate, sometimes lobed, terminal leaflet usually largest; stem leaves absent or few, similar to but smaller than basal leaves. Inflorescence an axillary, densely-flowered raceme, in fruit lax and ascending and up to 9 cm long, usually not reaching above the leaves. Flowers bisexual, regular, 4-merous, small; pedicel 1–3 mm long; sepals elliptical, c. 1 mm long, green to violet; petals very narrow, c. 1 mm long, white; stamens 6, filaments linear; ovary superior, ellipsoid, 2-celled, style very short, stigma flat. Fruit a cylindrical silique 7–15 mm × 1–1.5 mm, dehiscing with 2 valves, many seeded. Seeds orbicular, c. 0.5 mm in diameter, red-brown, finely reticulate.

Rorippa comprises about 75 species and is distributed worldwide. From tropical Africa (Madagascar included) about 8 species are known.

Ecology *Rorippa madagascariensis* can be found in humid localities such as open river banks and edges of pools, sometimes along forest paths. It is mostly confined to the lowland, but may occur up to 1200 m altitude.

Genetic resources and breeding *Rorippa madagascariensis* is widespread and not in danger of genetic erosion.

Prospects *Rorippa madagascariensis* will remain a minor wild vegetable of local importance in times when other vegetables are scarce.

Major references Burkill, H.M., 1994; Jonsell, B., 1974; Jonsell, B., 1980; Jonsell, B., 1982b; Raponda-Walker, A. & Sillans, R., 1961.

Other references Exell, A.W., 1960; Jonsell, B., 1982a; Marais, W., 1970; Robyns, W. & Boutique, R., 1951.

Authors P.C.M. Jansen

RUMEX ABYSSINICUS Jacq.

Protologue Hort. bot. vindob. 3: 48, t. 93 (1777).

Family Polygonaceae

Chromosome number $2n = 54$

Synonyms *Rumex schimperi* Meisn. (1856).

Vernacular names Sorrel, dock, Spanish rhubarb (En). Oseille d'Abyssinie, oseille sango, surelle (Fr). Azedinha brava (Po). Mchachu, mchumvichumvi (Sw).

Origin and geographic distribution *Rumex abyssinicus* is widespread in tropical Africa, most commonly in the highlands, particularly in central and eastern Africa, and Madagascar.

Uses The tender shoots and leaves of *Rumex abyssinicus* are edible and widely used as a vegetable. They have an acid taste and are eaten fresh or cooked, alone or together with other vegetables. In Tanzania the stem is chewed like sugar cane for its sweetness and the leaves are eaten as an acidic snack by herdsmen, farmers and children. The rhizomes yield a yellow and red dye. The dye is used in Ethiopia in butter as a condiment, to give it a rich yellow colour and as protection against rancidness. The dye is also used to impart a red colour to the feet and hands of women. In Uganda the plant is occasionally cultivated to obtain the red dye for colouring wickerwork and mats of grass and raffia, in Rwanda to obtain the yellow dye. The plant is browsed by livestock.

Sap of the aerial parts is applied as a treatment for pneumonia and cough in eastern Africa. In Ethiopia the plant is used to treat jaundice and related liver diseases, scrofula, stomach-ache, neckache and low blood pressure, and as a wound dressing, haemostatic and depurative; the rhizome is used as a taenifuge. In DR Congo a leaf-compress is applied to areas of rheumatism, an infusion is taken as a purgative and root sap is applied against scabies. In Tanzania the stem and rhizome are believed to act as a galactagogue. The whole plant, fresh or dried, is ground up in Tanzania and placed on sores and parts affected by scabies. An extract of the rhizome is taken to control mild forms of diabetes in eastern Africa and, with water, to cure stomach-ache. Pounded rhizomes and roots are applied on wounds and are also considered to have purgative properties. In Rwanda and Tanzania crushed plants are used to scour clean cooking pots blackened over the fire and to remove grease.

Properties There is no information on the nutritional composition, but it is probably comparable to garden sorrel (*Rumex acetosa* L.), which is widespread in temperate regions. The following constituents have been found in *Rumex abyssinicus*: oxalic acid, chrysophanic acid, chrysophanol, emodine and physcion. Several substances are toxic, e.g. chrysophanic acid. The roots possess antibacterial activity against *Streptococcus pyogenes* (causing several dangerous infections and diseases) and anti-inflammatory activity by inhibiting the synthesis of prostaglandin (a substance produced by invaders counteracting defensive activities of the body). *Rumex abyssinicus* has strong antiviral activity against Coxsackie virus (causing a disease resembling poliomyelitis) and influenza A virus. In vitro it demonstrated proliferation of murine macrophage cells, suggesting that it may have a role in improving the immune system of the body and in the process of wound healing (promoting regeneration of epithelial cells).

Botany Very stout perennial herb up to 4 m tall, with fleshy rhizome and glabrous, red-green, grooved stem up to 3 cm in diameter at base. Leaves alternate, simple; ocrea funnel-shaped, 2–2.5 cm long, brown, easily torn; petiole often as long as the blade; blade triangular-hastate, basal leaves up to 25 cm × 20 cm with palmate venation, stem leaves much smaller. Inflorescence a large and richly branched, leafless panicle up to 50 cm long, with flowers in small clusters. Flowers usually bisexual; pedicel slender, up to 5 mm long; tepals 6, outer 3 ovate, 1.5 mm long, reflexed in fruit, brown, membranous, inner 3 cordate, 1–1.5 mm long during flowering, enlarging in fruit up to 6 mm long, green with red margins and distinct reticulate veins, red-brown in fruit. Fruit a sharply trigonous nut 2–4 mm long, shiny pale to dark brown.

Rumex comprises about 200 species, many originating from northern temperate regions. *Rumex abyssinicus* is variable, particularly in the leaves, and numerous varieties have been distinguished, but these are of little practical value because of many intermediates.

Ecology *Rumex abyssinicus* is a common weed in fields and plantations. It also occurs along paths and water, in secondary scrub, grassland and margins of rain forest, up to 3300 m altitude. In Tanzania it thrives on volcanic soils and sandy loams, where annual rainfall is 1100–2200 mm.

Management *Rumex abyssinicus* is usually

collected from the wild. As a weed it is often tolerated in fields and plantations. In Gabon, DR Congo, Rwanda and Uganda it is cultivated as a vegetable or as a dye producer. It can be propagated by seeds and after establishment by division. For optimum leaf production the inflorescences should be removed. Leaves are usually collected in the rainy season whenever needed.

Genetic resources and breeding *Rumex abyssinicus* is rather widespread and not in danger of genetic erosion. A large germplasm collection is kept in Germany (Gatersleben).

Prospects *Rumex abyssinicus* will remain locally an important vegetable from the wild. Its nutritive and medicinal properties deserve better investigation, also because related plants have been used in treating schistosomiasis.

Major references Burkill, H.M., 1997; Graham, R.A., 1958; Hedberg, O., 2000; Katende, A.B., Ssegawa, P. & Birnie, A., 1999; Ruffo, C.K., Birnie, A. & Tengnäs, B., 2002.

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Authors P.C.M. Jansen

RUMEX NEPALENSIS Spreng.

Protologue Syst. veg. 2: 159 (1825).
Family Polygonaceae
Chromosome number $2n = 40$, 120
Synonyms *Rumex steudelii* Hochst. ex A.Rich. (1850), *Rumex bequaertii* De Wild. (1929), *Rumex quarrei* De Wild. (1929).

Vernacular names Dock, sorrel (En). Canaigre du pays (Fr).

Origin and geographic distribution *Rumex nepalensis* is widespread throughout Africa and the Mediterranean to eastern Asia.

Uses The leaves and young shoots are locally eaten as a cooked vegetable, but often only in times of scarcity and mixed with other vegetables. In tropical Africa the use as a vegetable is recorded from Rwanda, Kenya and Malawi, and it is also used in South Africa.

In Ethiopia an aqueous rhizome extract is drunk to treat rheumatism, colic, stomach-ache and abdominal pains caused by intestinal parasites. In Tanzania and Ethiopia the roasted rhizome is applied to abscesses and crushed leaves to wounds. The herb is also considered as a medicine for cough and headache, as a laxative, antidote and depurative. In South Africa a strong leaf decoction is said to be effective for schistosomiasis. In Malawi an infusion of the root, often mixed with other ingredients, is used to cure pneumonia, dysentery and venereal diseases. In Rwanda the plant is used to clean blackened cooking pots, and in India the rhizome for dyeing.

Properties There is no information on the nutritional composition, but it is probably comparable to garden sorrel (*Rumex acetosa* L.), which is widespread in temperate regions. The rhizome of *Rumex nepalensis* contains tannin (about 4%), chrysophanic acid (rumicin) and nepodin (nepalin). An aqueous and ethanol extract of the leaves showed antihistaminic, anticholinergic or antibradykinin activities on rabbit skin in vivo.

Botany Stout, erect, rhizomatous perennial herb up to 1(–2) m tall, with green or pale brown stem. Leaves alternate, simple; ocrea tubular; lower leaves long-petiolate, upper leaves shortly petiolate; blade of lower leaves oblong-ovate, 20–33 cm × 12–20 cm, base cordate, margins undulate-denticulate, crispy or flat, puberulous beneath, blade of cauline and upper leaves broadly ovate-lanceolate, base cordate to rounded or subtruncate. Inflorescence a panicle with spreading branches, almost leafless, with somewhat remote whorls of flowers. Flowers unisexual, usually pendulous; tepals 6, reticulately veined; inner 3 oblong-ovate, 3–5 mm long in fruit, each margin with 5–6 hooked teeth, apex circinately incurled, at least 1 segment with pronounced fusiform tubercle (swollen midvein). Fruit a sharply trigonous, ovoid nut 3–5 mm × 2–2.5 mm, glossy brown.

Rumex comprises about 200 species, many originating from northern temperate regions.

Ecology *Rumex nepalensis* occurs as a weed in disturbed habitats, and in moorland, grassland and bushland at 700–4000 m altitude.

Management *Rumex nepalensis* is collected from the wild and is not cultivated.

Genetic resources and breeding *Rumex nepalensis* is widespread and not in danger of genetic erosion. A large germplasm collection is kept in Germany (Gatersleben).

Prospects *Rumex nepalensis* will remain a minor vegetable and medicinal plant, which is only locally important. More research is needed

to evaluate its nutritional and medicinal properties.

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Other references Aggarwal, P.K., Kumar, L., Garg, S.K. & Mathur, V.S., 1986; Decary, R., 1946; Jansen, P.C.M., 1981; Kokwaro, J.O., 1993; Nguyen Thi Do, 2001b; Rechinger, K.H., 1954; Robyns, W., 1948b; van Wyk, B.E. & Gericke, N., 2000; Westphal, E., 1975; Williamson, J., 1955.

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RUMEX VESICARIUS L.

Protologue Sp. pl. 1: 336 (1753).

Family Polygonaceae

Chromosome number $2n = 18$

Vernacular names Sorrel, bladder dock, rosy dock (En).

Origin and geographic distribution In Africa *Rumex vesicarius* occurs in drier regions from Mauritania and Mali east to Sudan, Ethiopia and Somalia; outside Africa from the Mediterranean east to India. It has occasionally been tried with success in more humid areas, e.g. in Tanzania. In other areas, e.g. Australia, it has become a difficult to eradicate weed after introduction.

Uses In several parts of the Sahara and Sahel regions *Rumex vesicarius* is eaten as a vegetable, e.g. in Mauritania, Mali and Sudan. In India it is considered a famine food and the leaves are first boiled. It is grazed by livestock.

Botany Annual or perennial, shrubby, rhizomatous herb up to 50 cm tall, strongly branched from the base, with young herbaceous green stems turning brown and woody when older. Leaves alternate, simple; ocrea funnel-shaped, up to 8 mm long; petiole about as long as blade; blade triangular to oblong-triangular, up to 7 cm × 4 cm, cuneate to truncate at base, glabrous but with small warts all over the surface. Inflorescence a dense axillary or terminal panicle. Flowers bisexual or male; tepals 6, inner 3 cordate, c. 3 mm long at flowering, enlarging to 2 cm in fruit and then with conspicuous red reticulate venation, 2 tepals of each flower with tubercles (swollen midvein). Fruit a trigonous nut 3–5 mm long, brown.

Rumex comprises about 200 species, many originating from northern temperate regions.

Ecology *Rumex vesicarius* grows in dry areas among loose stones, on grassy or gravelly slopes, from sea-level up to 1150 m altitude.

Management *Rumex vesicarius* is collected from the wild and not cultivated. Sometimes it has become a cumbersome weed.

Genetic resources and breeding *Rumex vesicarius* is widespread and not in danger of genetic erosion. A large germplasm collection is maintained at Gatersleben, Germany.

Prospects *Rumex vesicarius* will remain an interesting vegetable for dry areas where other foods are scarce. Research is needed to evaluate its nutritional value.

Major references Burkill, H.M., 1997; Hedberg, O., 2000; Thulin, M., 1993b.

Other references Rechinger, K.H., 1954.

Authors P.C.M. Jansen

SALICORNIA PACHYSTACHYA Bunge ex Ung.-Sternb.

Protologue Vers. Syst. Salicorn.: 51 (1866).

Family Chenopodiaceae (APG: Amaranthaceae)

Synonyms *Arthrocnemum pachystachyum* (Bunge ex Ung.-Sternb.) A.Chev. (1922), *Salicornia perrieri* A.Chev. (1922).

Vernacular names Glasswort, samphire (En). Salicorne (Fr).

Origin and geographic distribution *Salicornia pachystachya* grows along the coast of eastern Africa, from Kenya to South Africa, and of Madagascar and other African Indian Ocean islands.

Uses Young shoots of *Salicornia pachystachya* are collected from the wild and eaten fresh in salads or as a garnish, pickled in vinegar, or as a cooked vegetable, similar to other *Salicornia* species outside Africa. The plant is also a good forage for many animals. It is said that juice of the fresh plant is an excellent diuretic.

Properties *Salicornia pachystachya* is rich in salt. Formerly, the ash of *Salicornia* species was used for washing.

Botany Erect, annual, glabrous herb up to 40 cm tall; stem with numerous suberect or ascending lateral branches, seemingly leafless, built up of numerous superposed, more or less tubular succulent segments, each segment at apex forming a little cup with 2 short teeth embracing the base of the next higher segment; sterile segments cylindrical, 5–10 mm × 2–4 mm, faintly keeled with lateral ridge, glaucous to brown-red; fertile segments aggregated into spikes 1–2.5 cm long at the end of stem and

branches. Flowers in clusters of 3, a pair of clusters to each fertile segment, small, immersed, bisexual, protandrous; perianth tubular, minutely 3-toothed; stamens usually 2 per flower; ovary superior, 1-celled, stigma tufted, with 2–3 lobes. Fruit a nut. Seed compressed ellipsoid, c. 1.5 mm long, testa thin, membranous, minutely hairy, brown; embryo folded so that radicle and cotyledons point downward; endosperm absent.

Salicornia comprises 30–40 species, and is distributed worldwide, mostly in saline habitats along coasts. Its taxonomy is not yet well established. The delimitation of *Salicornia pachystachya* is disputed. Specimens growing less upright with narrower (up to 4 mm in diameter) and more tapering fruiting spikes are often considered to belong to a separate species: *Salicornia perrieri* A.Chev. In southern Africa flowering is from June to October, fruiting from December to January.

Ecology *Salicornia pachystachya* grows in salt marshes and mangrove swamps at sea-level near coasts.

Genetic resources and breeding *Salicornia pachystachya* is widespread and does not seem to be in danger of genetic erosion.

Prospects *Salicornia pachystachya* will remain an interesting vegetable with a distinctive taste. *Salicornia* in general is becoming more and more appreciated in haute cuisine cooking, and there may also be an increasing demand for *Salicornia pachystachya*. Its nutritional composition and cultivation requirements on commercial scale deserve more investigation.

Major references Brenan, J.P.M., 1964; Brenan, J.P.M., 1988; Decary, R., 1946; van Wyk, B.E. & Gericke, N., 2000; Wilson, P.G., 1984.

Other references Cavaco, A., 1954b; O'Callaghan, M., 1992; Tölken, H.R., 1967.

Authors P.C.M. Jansen

SAMOLUS VALERANDI L.

Protologue Sp. pl. 1: 171 (1753).

Family Primulaceae (APG: Theophrastaceae)

Chromosome number $2n = 26$

Vernacular names Brookweed, water pimpernel (En). Mouron d'eau (Fr). Alface dos rios, coentro de tchincherrote (Po).

Origin and geographic distribution *Samolus valerandi* is an almost cosmopolitan herb of humid localities in tropical to temperate regions, and occurs throughout tropical Africa.

Uses The young leaves of *Samolus valerandi* are collected from the wild and eaten as a cooked vegetable or raw as a salad, but mostly only in times when other vegetables are scarce. In southern Africa the plant is used as a remedy for itch, ringworm and other skin rashes. The plant is sometimes cultivated as an ornamental in water borders; some types survive submersion for some months, but *Samolus valerandi* is not recommended as an aquarium plant.

Botany Erect, glabrous, annual to short-lived perennial herb up to 50(–90) cm tall; stem simple or branched, arising from a basal rosette. Leaves alternate, simple, fleshy; rosette leaves with petiole up to 3 cm long, spatulate, 4.5–10 cm × 1.5–3.5 cm, stem leaves usually gradually becoming smaller and subsessile. Inflorescence an axillary or terminal, many-flowered raceme up to 25 cm long. Flowers bisexual, regular, 5-merous; pedicel 1–2.5 cm long, usually abruptly bent near the middle where a bract is attached; calyx cup-shaped, tube c. 1.5 mm long and partly adnate to ovary, lobes triangular, about half as long as tube; corolla campanulate, c. 2 mm long, with spatulate lobes, white; stamens inserted at base of corolla tube, alternating with staminodes inserted between the corolla lobes; ovary half-inferior, globose, style 0.5 mm long, stigma rounded. Fruit a globose capsule c. 3 mm in diameter, dehiscing with 5, strongly reflexed valves, many-seeded. Seeds angular, c. 0.5 mm long, minutely granular, dark brown. Seedling with epigeal germination; hypocotyl 1–2 mm long, epicotyl absent; cotyledons leafy, oblong-elliptical, 1–1.5 mm long.

Samolus comprises about 9 species, with only *Samolus valerandi* being cosmopolitan, the others mostly found in the Southern Hemisphere. Dispersion of *Samolus valerandi* seeds is probably effected by birds and by wind.

Ecology *Samolus valerandi* grows at water level on stream banks, in swamps, in drying riverbeds, along coasts and in dunes. It is tolerant of saline soils. Seed germinates only in light, does not survive long in salt water and seedlings die in sea water.

Genetic resources and breeding *Samolus valerandi* is extremely widespread and not in danger of genetic erosion.

Prospects *Samolus valerandi* will remain a minor vegetable, particularly of importance in times of food scarcity. Its nutritional composi-

tion and medicinal properties need investigation.

Major references Burkill, H.M., 1997; Hegi, G., 1927; Kupicha, F.K., 1983.

Other references Boutique, R., 1971; Figueiredo, E., 1995a; Taylor, P., 1958; Watt, J.M. & Breyer-Brandwijk, M.G., 1962.

Authors P.C.M. Jansen

SCHOUWIA PURPUREA (Forssk.) Schweinf.

Protologue Bull. Herb. Boiss. 4, append. 2: 183 (1896).

Family Brassicaceae (Cruciferae)

Chromosome number $2n = 36$

Synonyms *Schouwia schimperi* Jaub. & Spach (1847), *Schouwia thebaica* Webb (1847).

Vernacular names Alouât (Fr).

Origin and geographic distribution *Schouwia purpurea* is distributed from Mauritania, throughout the Sahel, Sahara and northern Africa to Djibouti and Somalia; also in Arabia.

Uses The Touareg people collect the leaves of *Schouwia purpurea* from the wild and eat them either cooked or dried without salt. The young leaves add an agreeable flavour to a salad, similar to that of garden rocket (*Eruca vesicaria* (L.) Cav.). The plant is relished by camels, green or dry, less by other livestock, and when fresh it appears to reduce the camels' need for water. Dry plants serve as fuel.

Properties The composition of fresh leaves and flowering tops of *Schouwia purpurea* as animal feed is per kg: fat 13 g, protein 70 g, mineral content 62 g (of which 17 g insoluble in HCl), P 1.8 g, N 11.3 g, C/N ratio 23.7 (Adam, J.G., 1966).

Botany Erect, glabrous, annual herb up to 1 m tall; stem becoming woody at base, branched in upper part. Leaves alternate, simple, sessile and clasping the stem at base, rather fleshy; blade ovate, 2–6 cm × 1.5–4 cm, upper leaves gradually becoming smaller, margin sinuate-dentate to almost entire. Inflorescence corymbose when flowering, in fruit elongating to a lax raceme. Flowers bisexual, regular, 4-merous; pedicel up to 7 mm long in fruit; sepals slightly saccate at base, 5–10 mm long; petals obovate-oblong to spatulate, 7.5–15 mm × 3–5 mm, purple-violet to white; stamens 6, filaments linear, anthers mucronate at apex; ovary superior, 2-celled, stigma conical, 2-lobed. Fruit a circular silique, flattened and winged, 1.5–3.5 cm in diameter with an up to 1 cm long beak, dehiscing with 2 valves, many-seeded. Seeds globose, c. 2 mm in diameter, red-brown, rather smooth.

Schouwia comprises only one variable species. In the past 2 species were distinguished: *Schouwia purpurea* occurring in the western part (less woody, with smaller flowers and fruits) and *Schouwia thebaica* occurring in the eastern part (more woody, larger flowers and fruits). In the literature, these are sometimes distinguished as subspecies of *Schouwia purpurea*.

Schouwia purpurea is of entomological importance since it provides feed and shelter for the desert locust *Schistocerca gregaria*, which sometimes develops migrating populations of plague size and may destroy crops completely.

Ecology *Schouwia purpurea* is a desert and savanna plant. It may occur in large stands after rains, from sea-level up to 1500 m altitude.

Genetic resources and breeding *Schouwia purpurea* is widespread and not in danger of genetic erosion.

Prospects *Schouwia purpurea* will remain a minor vegetable, which may, however, be important as a source of food and fodder in the Sahel and Sahara.

Major references Burkill, H.M., 1985; El Naggar, S.M. & Soliman, M.A., 1999; Jafri, S.M.H., 1977; Jonsell, B., 1993.

Other references Adam, J.G., 1966a; Jonsell, B., 2000; Maire, R., 1967; Moggi, G., 1967.

Authors P.C.M. Jansen

SCORZONERA HISPANICA L.

Protologue Sp. pl. 2: 791 (1753).

Family Asteraceae (Compositae)

Chromosome number $2n = 14, 28$

Vernacular names Scorzonera, black salsify, black oysterplant (En). Scorsonère, salsifis noir, salsifis (Fr). Escorcioneira, escorzonera (Po).

Origin and geographic distribution Scorzonera is a native of central and southern Europe. The first reports of cultivation are from the 17th century. It is grown in temperate climates throughout the world but seldom on a commercial scale; Belgium is the biggest producer with approximately 2000 ha planted every year. Scorzonera has been introduced in the highlands of tropical Africa and has been found occasionally as an escape from cultivation. It is occasionally cultivated in DR Congo, Kenya, Tanzania and Mauritius.

Uses Scorzonera roots are used as a cooked vegetable. They are peeled before or after boiling. In Europe, they are among the many canned and frozen commercial vegetables ('salsifis' in France). Young leaves are used as a salad.
The roots have been used, like chicory (*Cichorium intybus* L.), as a coffee substitute. Medicinal uses as a diuretic, sudorific and depurative are reported from Spain and Portugal. A mixture of latex and milk is used as a cure for colds. Ground fresh leaves are used to soothe the pain caused by viper bites.

Properties Scorzonera roots contain per 100 g edible portion (66%): water 83.3 g, energy 113 kJ (27 kcal), protein 1.3 g, fat 0.3 g, carbohydrate 10.2 g, Ca 42 mg, P 42 mg, Fe 0.9 mg, thiamin 0.06 mg, riboflavin 0.01 mg, niacin 0.2 mg, folate 57 µg, ascorbic acid 3 mg (Holland, B., Unwin, I.D. & Buss, D.H., 1991). The roots have a subtle, delicate, sweet flavour that many find too bland. Carbohydrate in the roots has a high proportion of inulin and laevulin, which make it an important foodstuff in diabetic diets. Scorzonera also contains conopherin, asparagine, arginine, histidine, choline and several immunomodulatory substances. The flowers have an aroma reminiscent of cocoa. Oil content of the seeds is 17.7%.

Botany Perennial, erect, branched herb up to 130 cm tall; taproot fleshy with black-brown skin, white inside. Leaves alternate, simple, long and gradually narrowed at base, linear to lanceolate, 15–40 cm × 0.5–6 cm, apex acuminate, entire or dentate, parallel-veined. Inflorescence a terminal head; involucre 2–3 cm long. Florets with yellow ligule, sometimes purplish outside, up to twice as long as involucre. Fruit an achene up to 2 cm long, with dirty white, plumose pappus.
In Europe, uses are similar for scorzonera, *Scolymus hispanica* L. and *Tragopogon porrifolius* L., all belonging to the same family.

Ecology In its native region in Mediterranean Europe, scorzonera grows in dry pastures and thickets on rocky ground. Once established, it resists drought well.

Management Scorzonera is best grown on light sandy soils to encourage formation of long, smooth roots. Seed storage behaviour is orthodox and the 1000-seed weight is about 12 g. A recommended plant density is 66,000 plants per ha. In Europe sowing is done in spring, harvesting in autumn. About 9 weeks after sowing roots reach their maximum length and subsequently increase in diameter. Yields of 8 t per ha can be achieved, with individual roots of 100–200 g. Roots do not store well.

Genetic resources and breeding Several collections are held in germplasm banks in Europe. There are several cultivars available in Europe. Research in Belgium centres on breeding, cultivar selection and control of pests, diseases and weeds. A male sterile line has been patented.

Prospects Scorzonera will remain a small-scale crop for the specialty market in urban centres. The international market is restricted to canned and frozen products as fear of soil contamination prohibits imports of fresh roots.

Major references CRI, 2003; Hernández Bermejo, J.E. & León, J. (Editors), 1994; Lawalrée, A., Dethier, D. & Gilissen, E., 1986; Moore, D., Tutin, T.G. & Walters, S.M., 1976.

Other references Beentje, H.J., 2000; Rubatzky, V.E. & Yamaguchi, M., 1997; van den Bergh, M.H., 1993.

Authors C.H. Bosch

SECAMONE STUHLMANNII K.Schum.

Protologue Engl., Pflanzenw. Ost-Afrikas C: 325 (1895).

Family Asclepiadaceae (APG: Apocynaceae)

Synonyms *Secamone whytei* N.E.Br. (1898), *Secamone floribunda* N.E.Br. (1902), *Secamone phillyreoides* S.Moore (1905), *Secamone rariflora* S.Moore (1905).

Origin and geographic distribution *Secamone stuhlmannii* is found in Rwanda, Kenya, Uganda, Tanzania and Malawi.

Uses In times of scarcity the leaves of *Secamone stuhlmannii* are eaten cooked as a vegetable in Malawi. The fibrous stems are used for rope. In East Africa a root decoction is used against stomach problems.

Botany Liana containing latex, the whole plant rusty-pubescent with spreading hairs. Leaves opposite, simple; petiole up to 5 mm long; blade oblong or ovate to lanceolate-elliptical, 1–6 cm × 0.5–2 cm, base rounded to acute, apex rounded to acute, margin entire. Inflorescence a terminal or axillary cyme, up to 6-flowered; peduncle up to 12 mm long. Flowers bisexual, regular, 5-merous, sweetly scented; pedicel up to 8 mm long; calyx with ovate lobes up to 1.5 mm × 0.5 mm, ciliate; corolla tubular with lobes up to 3 mm long, yellow; corona with triangular or falcate lobes, attached near the base of the staminal column and about one third of its length; ovary supe-

rior, apical portion of stigma head exserted for about 1 mm from the top of the staminal column. Fruit a pair of follicles, each one 6–10 cm × 1 cm, tapering gradually to a drawn-out point, silvery brown or olive-green, striate, puberulent. Seeds 7–10 mm × 1–1.5 mm, red-brown, with a coma of white hairs at apex.

Secamone comprises about 80 species, and is native to the tropics and subtropics of the Old World; 62 species are recorded for Madagascar, 16 for continental Africa, 1 for southern India and Sri Lanka and 1 for South-East Asia and Australia. Together with related genera it is in need of revision because the boundaries are not clear.

Ecology *Secamone stuhlmannii* is found in riverine bushland and thickets, at altitudes between 800–1700 m.

Genetic resources and breeding *Secamone stuhlmannii* is widespread and does not seem in danger of genetic erosion.

Prospects More research is needed to evaluate the nutritional and medicinal value of *Secamone stuhlmannii*.

Major references Goyder, D.J., 1992.

Other references Beentje, H.J., 1994b; Kokwaro, J.O., 1993; Williamson, J., 1955.

Authors P.C.M. Jansen

SECHIUM EDULE (Jacq.) Sw.

Protologue Fl. Ind. occid. 2(2): 1150 (1800).

Family Cucurbitaceae

Chromosome number $2n = 26$, 28

Vernacular names Chayote, choyote (En). Chayote, chouchou, chouchoutte, christophine, mirliton (Fr). Chuchú, chahiota, caiota, pepinela, chocho (Po).

Origin and geographic distribution The centre of origin and domestication of *Sechium edule* is southern Mexico and Guatemala, where wild types are still found. The Aztecs and Mayas already cultivated chayote in pre-Columbian times, but fossil records are lacking. It has now spread throughout the tropics and subtropics. In tropical Africa it occurs in many areas as a minor fruit and leaf vegetable, e.g. in East Africa, Madagascar and the Mascarene Islands. In Réunion and Mauritius it is locally naturalized.

Uses Chayote is mainly grown for its immature or almost mature fruits, harvested before enlargement of the seed, and eaten as a cooked vegetable. In tropical America and Asia also young, small fruits and young leaves and

Sechium edule – planted

shoots are used as vegetables, whereas the tuberous roots are consumed especially in Central America. In Jamaica the seeds are eaten fried or roasted. In the Mascarene Islands chayote shoots ('brède chouchou') are an important component of local dishes, besides the fruits. The fruits vary in flavour from bland or starchy to sweetish, depending on the cultivar. Fruits of bland cultivars are used industrially as food filler for pastes and sauces. Because of its low energy value, chayote is gaining importance as a dietary food in hospitals and nursing homes. Chayote fruits are also considered good baby food. The seed is nutlike in flavour and a source of protein. Fruits, shoots and tubers are used as fodder for pigs, poultry and cattle. In the past, fibres from the stem have been used to make baskets and hats and – as reported from Ghana – as binding material in the construction of mud houses. During the 19th and early 20th centuries, Réunion had an important home industry of hats and other artefacts for export made from these attractive fibres, called 'paille de chouchou'. The leaves of chayote are said to possess cardiovascular modifying as well as blood pressure lowering properties and to dissolve kidney stones. The tubers are a potent diuretic and are also applied for pulmonary ailments and relief of intestinal inflammation. Medicinal uses of chayote have not been reported from Africa.

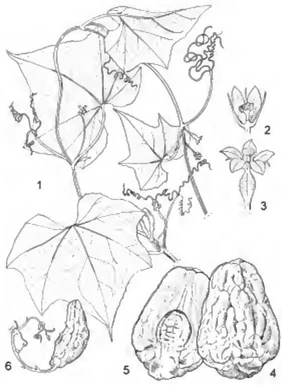
Production and international trade In quantity chayote is one of the leading market vegetables in Central and South America and in South-East Asia, but its commercial value is low. There is considerable international trade, e.g. for export to Europe and the United States.

In tropical Africa, it is locally of some importance, e.g. in Sierra Leone, Ghana, Malawi, Réunion and Mauritius, but no statistical data on production or trade are available.

Properties The edible portion of chayote fruits is about 86%. The average nutritional composition of fruits per 100 g edible portion is: water 94 g, energy 80 kJ (19 kcal), protein 0.8 g, fat 0.1 g, carbohydrate 4.5 g, dietary fibre 1.7 g, Ca 17 mg, Mg 12 mg, P 18 mg, Fe 0.3 mg, Zn 0.7 mg, vitamin A 56 IU, thiamin 0.03 mg, riboflavin 0.03 mg, niacin 0.47 mg, folate 93 μg, ascorbic acid 7.7 mg (USDA, 2002). The young leaves and shoots contain per 100 g: water 90 g, energy 251 kJ (60 kcal), protein 4.0 g, fat 0.4 g, carbohydrate 4.7 g, fibre 1.2 g, Ca 58 mg, P 108 mg, Fe 2.5 mg, vitamin A 615 μg, thiamin 0.08 mg, riboflavin 0.18 mg, niacin 1.1 mg, ascorbic acid 16 mg. The tuberous roots contain per 100 g edible portion (73% of total): water 80 g, energy 331 kJ (79 kcal), protein 2.0 g, fat 0.2 g, carbohydrate 17.8 g, fibre 0.4 g, Ca 7 mg, P 34 mg, Fe 0.8 mg, thiamin 0.05 mg, riboflavin 0.03 mg, niacin 0.9 mg, ascorbic acid 19 mg (Engels, J.M.M., 1983).

Extracts of *Sechium edule* showed antimutagenic activity in a *Salmonella typhimurium* assay. The ribosome-inactivating protein sechiumin was purified from the seeds. It has been suggested that this compound could be used for the preparation of immunotoxin as a potential cancer chemotherapeutic agent. Fruit extracts exhibited hypotensive effect in tests with rats. Chayote may cause hypokalaemia in pregnancy.

Description Monoecious, perennial herb, sprawling or climbing with large, 2–5-branched tendrils; root large, tuberous; stem up to 15 m long, longitudinally grooved. Leaves arranged spirally, simple; stipules absent; petiole 3–25 cm long; blade broadly ovate-circular in outline, 7–25 cm in diameter, 3–7-angular or lobed, base deeply cordate, margins obtusely toothed, scabrid hairy, 5–7-veined from the base. Flowers unisexual, regular, 5-merous; male flowers in an axillary raceme, small, greenish or cream, stamens 3, with filaments united; female flowers usually solitary on short pedicel, corolla c. 0.5 cm in diameter, ovary inferior, 1-celled, style short, stigma headlike. Fruit a fleshy berry, variable in shape but commonly pear-shaped, 4–27 cm long, somewhat ribbed, smooth or shortly spiny, dark green to almost white, pulp white or greenish-white, 1-seeded. Seed ovoid to ellipsoid, compressed, 2.5–5 cm long, white.



Sechium edule – 1, flowering and fruiting shoot; 2, male flower in longitudinal section; 3, female flower; 4, fruit; 5, fruit in longitudinal section; 6, fruit with germinating seed.
Source: PROSEA

Other botanical information *Sechium* comprises about 10 species. Only *Sechium edule* and *Sechium tacaco* (Pittier) C.Jeffrey are cultivated, the latter only in Costa Rica. Wild types of *Sechium edule* differ from cultivated types by their more robust growth and larger leaves, flowers and male inflorescences; the pulp of their fruits is bitter and usually more fibrous. *Sechium compositum* (J.D.Sm.) C.Jeffrey, occurring in southern Mexico and Guatemala, is considered the closest wild relative of *Sechium edule*. Its fruit is bitter and both spiny and spineless types have been found. Chayote cultivars do not breed true, although it has been observed that cultivars do not segregate significantly from one generation to the next because of the relative isolation of chayote plants from one another when planted in home gardens. Many types with different fruit characters are known. Commercially grown chayote consists of two types: one with a medium-sized, pale green, smooth, pear-shaped fruit and one with a small, white, smooth, globular fruit.

Growth and development Chayote is a

long-lived perennial, but in cultivation it is recommended to renew it at least every 3 years because of disease problems. The tubers do not develop until the second year, and do not develop well in climates without a dry season. In regions with a season of arrested growth, they can reach 10 kg in weight and resemble yam tubers. Flowering starts 1–2 months after germination. Flowers are pollinated by insects. Chayote is self-compatible; single plants show good fruit set and there are no clear inbreeding symptoms. In addition, parthenocarpy has been reported. Chayote is a renowned honey-producing plant, loved by beekeepers because it flowers abundantly throughout the year. Fruit development takes 1–2 months after pollination. In good conditions, chayote plants grow profusely and can form a dense foliage cover on trellis, producing hundreds of hanging fruits. The seed germinates in the ripe fruit while still on the mother plant. The stem of the seedling grows out from the fruit apex and curves upwards. It produces roots which abort when they do not make contact with soil.

Ecology The natural habitat of wild chayote is montane rainforest on steep hillsides. Chayote requires high relative humidity (80–85%) and well-distributed annual rainfall of at least 1500–2000 mm (or irrigation). Growth and fruit set are strongly influenced by day and night temperatures. Chayote succeeds at average day temperatures of 15–28°C (optimum 25°C) and at average night temperatures below 23°C. Temperatures below 13°C cause damage to small unripe fruits, and temperatures above 28°C lead to excessive vegetative growth and the falling of flowers and unripe fruits. In West Africa chayote does not set fruit at sea-level, but produces well at 350–2500 m altitude. At higher latitudes, it grows and produces well in lowlands, but the production stops during the hottest months. In the Antilles, chayote produces fruit at sea-level only during the cool season, at medium elevations the whole year round, and at 1600 m altitude only during the warmest months. Some observers consider chayote as day-neutral, others as a slightly short-day plant. The photoperiodism and the relation between temperature and fruit set need further clarification. Chayote is susceptible to drought and wind, and is killed by night frost. It grows best in a rich well-drained, rather loose sandy loam soil.

Propagation and planting Chayote is propagated by placing a whole fruit on its side in a hollow scooped out at the foot of a trellis support and covering the fruit slightly with soil and farmyard manure. Sometimes up to 4 fruits already bearing sprouts of 10–12 cm long are planted in the same pit. Immersion of the fruit for several minutes in a fungicide and insecticide solution provides protection against diseases and pests. The plants are usually spaced 1.5 m apart along a fence or trellis, but when they are allowed to sprawl they need much more space.

Management A trellis support must be provided for optimum growth, but in the Mascarene Islands chayote is grown without any support. In gardens, plants can be trained over a fence, porch or tree. In trees they may grow to a height of more than 10 m. They are best planted where there is some shelter from strong winds. Chayote requires large quantities of water (about 50 mm per week) and should be abundantly irrigated in periods of drought. Incorporation of manure or compost is recommended, as well as application of NPK before planting followed by regular topdressing with nitrogen fertilizer or liquid manure until fruit formation. In the Antilles incorporation of farmyard manure every 3 months is recommended. In India ammonium sulphate and superphosphate at the rate of 1 kg and 0.5 kg respectively per pit are applied in two doses before flowering. In some parts of the world, the plants are pruned at the end of the season, leaving only a small portion of about 1.5 m of the stem.

Diseases and pests Chayote is in general not very susceptible to pests and diseases, but it is often heavily attacked by root-knot nematodes. Application of large amounts of organic manure to the planting holes reduces damage. Chayote plants sometimes suffer from mosaic virus. Powdery mildew (*Erysiphe cichoracearum*), downy mildew (*Pseudoperonospora cubensis*) and leaf spot (*Mycosphaerella* sp.) occur but are rarely serious. In Trinidad a disease called web blight and caused by the fungus *Thanatephorus cucumeris* has been reported. Spider mites and insects such as leaf beetles may cause some damage. The use of pesticides may lead to reduction in yield by killing pollinating insects. Because of nematodes and other disease problems, chayote crops are usually removed at the end of a 3-year cultivation period.

Harvesting Chayote plants start production of fruits 3–5 months after planting and a fruit needs 4–6 weeks from pollination to market size (usually about 0.5 kg). The fruits are hand-

picked at an immature stage, when they have reached full size but before the enlargement of the seed. Harvesting late gives fibrous fruits, harvesting early watery ones that do not keep well. Traditionally, maturity is tested by lightly pressing the fruit skin with a finger nail; the right stage is reached if this does not dent the skin. To harvest tubers, it is not necessary to kill the plant; individual tubers can be carefully dug up, while the plant continues to produce fruits and new tubers.

Yield Production can be seasonal or almost continuous, depending on the climate, and annual yields may range from 75–300 or more fruits per plant. In commercial plantations, yields of 20–30 t/ha have been reported.

Handling after harvest When fruits are stored in a cool and dark place, sprouting will start after approximately 2 weeks. In cold storage, at 9–11°C and high relative humidity and wrapped in plastic, the fruits keep well for several weeks.

Genetic resources Chayote seed cannot be stored for much longer than one month since it is viviparous and has no dormancy. Long-term maintenance of germplasm collections must therefore be in the form of living plants in field genebanks, or as tissue cultures under slow growth conditions. Promising results have been obtained in Costa Rica with cryopreservation of shoot tissue. Germplasm collections are at present held by CATIE (Turrialba, Costa Rica), Centro Regional Universitario Oriente (CRUO) of the Autonomous University of Chapingo (Huatusco, Vera Cruz, Mexico), INIA (Celaya, Guanajuato, Mexico), EMBRAPA (Brasilia, Brazil) and Tribhuvan University (Kathmandu, Nepal). Genetic erosion of chayote in its centre of diversity is accelerating as a result of replacement of landraces by a few improved cultivars. Collection and evaluation of landraces is required, as well as the evaluation of wild relatives of chayote, especially for finding disease resistances.

Breeding Efforts made at CATIE (Costa Rica) to describe cultivars on the basis of fruit characteristics proved to be of limited relevance because of the extraordinary variability, with continuous variation in almost all characters, including size (4–27 cm long), weight (60–1200 g), colour (continuous range from white to dark green), shape (pear-shaped, ovoid, flattened globular), fruit-wall features (spines, lenticels, grooves and ridges), flavour and texture. Micro-cuttings are being used in Costa Rica to propagate selected genotypes for commercial production on large acreages. Commercial production is limited by disease problems as well as by the demand for quality fruits; consequently, a breeding programme with these two objectives is needed. However, private seed companies are not interested in chayote because it is viviparous. In Ghana a type called 'Ivory White' is grown. Bland cultivars are required for the industrial market and tasty ones for the table-vegetable market.

Prospects Chayote is a multipurpose, high-yielding and easy-to-produce vegetable, suitable for home gardens and market production, meriting promotion in tropical Africa.

Major references Abbiw, D.K., 1990; Aung, L.H., Ball, A. & Kushad, M., 1990; Engels, J.M.M., 1983; Engels, J.M.M., 1984; Engels, J.M.M. & Jeffrey, C., 1993; Lira Saade, R., 1996; Newstrom, L.E., 1989; Newstrom, L.E., 1991; Newstrom, L.E., 1985; USDA, 2002a.

Other references Abdelnour, A., Ramirez, C. & Engelmann, F., 2002; Hernández Bermejo, J.E. & León, J. (Editors), 1994; Holland, B., Unwin, I.D. & Buss, D.H., 1991; Jensen, L.P. & Lai, A.R., 1986; Lira, R., Caballero, J. & Davila, P., 1997; Messiaen, C.-M., 1989; Monnerville, K. et al., 2001; Newstrom, L.E., 1986; Norman, J.C., 1992; Wu, T.H., Chow, L.P. & Lin, J.Y., 1998.

Sources of illustration Engels, J.M.M. & Jeffrey, C., 1993.

Authors J.M.M. Engels

Based on PROSEA 8: Vegetables.

SENNA OBTUSIFOLIA (L.) Irwin & Barneby

Protologue Mem. New York Bot. Garden 35: 252 (1982).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Chromosome number $n = 13, 14, 2n = 24$

Synonyms *Cassia obtusifolia* L. (1753), *Cassia tora* auct. non L.

Vernacular names Sicklepod, African foetid cassia, low senna (En). Séné, pistache marron, casse fétide (Fr).

Origin and geographic distribution *Senna obtusifolia* is found throughout tropical Africa with the exception of Madagascar. It is considered an early introduction into Africa from America, where it shows far more variation. In Africa the fruits are broad as in specimens from the Caribbean and southern United States, which suggests a Caribbean origin of the African plants. In Asia plants with broad

fruits are widespread, but in the Philippines only plants with needle-like fruits occur. *Senna obtusifolia* is considered a weed worldwide and an estimated 600,000 ha are infested in Queensland (Australia).

Uses The young, tender leaves of *Senna obtusifolia* are occasionally used as a vegetable throughout Africa and elsewhere and the plant is cultivated in home gardens for this purpose in several countries including Senegal, Ghana, Cameroon and Ethiopia. Older leaves, if eaten frequently or in large quantities, will cause diarrhoea.

Cattle, sheep, goats and ostriches browse the plants, but the growth stage of the plants may influence acceptability. In both Africa and the United States, mycotoxicosis is an often fatal disease of cattle grazing *Senna obtusifolia* and other *Senna* species.

The leaves are used as a laxative and as a poultice to treat skin infections, sores, ulcers and insect bites. The leaves are further used as an anthelminthic and against vomiting and stomach-ache. A decoction of the leaves is used to treat eye complaints in Senegal and Zanzibar. In DR Congo a fish poison is made from the crushed leaves. The roots are used as a laxative and anthelminthic. The seeds are eaten, combined with a leaf decoction, to treat conjunctivitis.

Roasted seeds have been used as a substitute for coffee, leaves for a tea-like infusion. The seeds, the macerated leaves and the roots provide black, blue, yellow and orange dyes. In Sudan the powdered and fermented leaves are used as a condiment. The stems are used to make mats and fences.

In Uganda the seeds are occasionally dried and ground into powder, which is cooked and eaten as a staple food in moderate amounts. The seeds have been eaten in times of famine in the Sahel region as well. As the seeds are reputedly poisonous, cooking or roasting is deemed necessary to make them safe to eat. The flowers are decorative and the plant is commonly planted as an ornamental near towns. In India the seeds are collected from the wild for the industrial extraction of gums (galactomannans) for the food industry.

Properties Fresh leaves of *Senna obtusifolia* contain per 100 g edible portion: water 79.7 g, energy 251 kJ (60 kcal), protein 5.6 g, fat 0.2 g, carbohydrate 12.5 g, fibre 2.3 g, Ca 589 mg, P 96 mg, Fe 5.9 mg, β-carotene 7.9 mg, thiamin 0.23 mg, riboflavin 0.71 mg, niacin 1.5 mg, ascorbic acid 113 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). The cooked vegetable tastes bitter but has an attractive consistency. The seeds contain 5.3% oil, the major components being linoleic acid 41%, palmitic acid 23% and oleic acid 22%. The seeds contain commercially interesting levels of gums.

The laxative properties of *Senna* species are attributed to anthroquinones. A yellow phenolic pigment, cassiaxanthone, has been isolated from the roots of *Senna* species. Mycotoxins, produced by fungi affecting *Senna*, may be the cause of death in cattle. *Myrothecium verrucaria*, a fungus isolated from *Senna obtusifolia*, is used for control of nematodes in food crops and ornamental plants and is widely tested as a herbicide against weeds like water hyacinth (*Eichhornia crassipes* (Mart.) Solms), *Chenopodium album* L. and *Senna obtusifolia* itself. Strains of *Fusarium oxysporum* and *Alternaria cassiae* were similarly obtained and showed considerable control of *Senna* species if applied at the pre-emergence stage.

Botany Annual or perennial herb or shrub up to 2(–2.5) m tall. Leaves alternate, imparipinnate with 3 pairs of leaflets; stipules linear or filiform; petiole without gland, rachis with prominent gland between 1–2 lower pairs of leaflets; leaflets obovate, (1–)1.5–5(–6) cm long, apex rounded or abruptly acuminate, mucronate. Inflorescence 1–2-flowered, with usually very short peduncle. Flowers bisexual, 5-merous; pedicel 1.5–3.5(–4.5) cm long; sepals ovate, c. 5 mm long; petals obovate, 1–2 cm long, yellow; stamens 10, lower 3 largest, 4 somewhat smaller and 3 very small, reduced; ovary superior, linear, curved. Fruit a linear, dehiscent pod up to 23 cm × 0.5 cm, straight or curved, many-seeded. Seeds rhomboid, c. 5 mm long, with a distinct areole. Seedling with epigeal germination; cotyledons semi-fleshy.

Until the beginning of the 1980s *Cassia* was considered to be a large genus of over 550 species, but then it was split into 3 genera: *Cassia* sensu stricto, *Senna* and *Chamaecrista*. *Cassia* now has only 30 species, whereas *Senna* and *Chamaecrista* comprise about 260 and 270 species, respectively. *Senna obtusifolia* is closely related to *Senna tora* L., but the latter can be recognized by its shorter pedicels. The distinction between *Senna obtusifolia*, *Senna occidentalis* (L.) Link and *Senna tora* is not always properly made; names have often been misapplied and vernacular names may apply to all of them. The presence of *Senna tora* in Africa is doubtful and references to it probably concern *Senna obtusifolia*.

Senna obtusifolia is a short-day plant, but exact light requirements for flower initiation differ by provenance. It is self-pollinating and interspecific crosses have not yielded viable seed.

Ecology *Senna obtusifolia* is found along rivers and on lake shores, as well as on cultivated land, up to 1700 m altitude.

Management Details on cultivation of *Senna obtusifolia* in Africa are unknown. In India seeds for gum production are presently harvested from the wild. As far as is known, *Senna obtusifolia* is only grown commercially in Korea for medicinal uses, with seed yields as high as 2.6 t/ha. Fertilizer applications of 80 kg N, 30 kg P and 50 kg K were optimal for seed production. Several fungi affect *Senna obtusifolia* and it is an alternative host of *Alternaria cassiae*, which affects e.g. cowpea (*Vigna unguiculata* (L.) Walp.) and several *Solanum* species.

Genetic resources and breeding While the wider genetic variation of *Senna obtusifolia* is found in the New World, there is obvious scope for selection for vegetable use even within the African populations. Farmers already select plants that taste less bitter, are less fibrous and have easy-to-pick leaves. Australia may start a breeding programme based on seed stock collected from all over the area of distribution in the near future. Breeding would aim at high seed and gum yield, good gum quality and adaptation to mechanized cultivation.

Prospects *Senna obtusifolia*, like many other *Senna* species, is a true multipurpose plant. A proper understanding of the variation will be essential for future developments. *Senna obtusifolia* will probably remain a minor vegetable. Seed gums are used worldwide for a variety of industrial applications. Increased demand and inconsistency of supply and price has driven industrial users to search for new sources of supply and *Senna obtusifolia* is a good alternative for locust bean (*Ceratonia siliqua* L.) and guar (*Cyamopsis tetragonoloba* (L.) Taub.). A patent restricting the use of *Senna obtusifolia* gum lapsed in 2002. The medicinal properties also seem to justify more research. However, the weedy nature and the toxic properties require caution.

Major references Burkill, H.M., 1995; Irwin, H.S. & Barneby, R.C., 1982; Katende, A.B., Ssegawa, P. & Birnie, A., 1999; Lock, J. M., 1990; Toruan-Purba, A.V., 1999.

Other references Cunningham, D. & Walsh, K., 2001; Dupriez, H. & De Leener, P., 1987; Schippers, R.R., 2000; Southon, I.W., Bisby, F.A., Buckingham, J. & Harborne J.B., 1994; Stevels, J.M.C., 1990; van den Bergh, M.H., 1993; Wagner, J.J., 1993; Walker, H.L. & Tilley, A.M., 1997.

Authors C.H. Bosch

SERICOSTACHYS SCANDENS Gilg & Lopr.

Protologue Bot. Jahrb. 27: 51 (1899).

Family Amaranthaceae

Chromosome number $2n = 22$

Synonyms *Sericostachys tomentosa* Lopr. (1899).

Origin and geographic distribution *Sericostachys scandens* is widespread in tropical Africa from Nigeria to Ethiopia and south to Angola and Malawi.

Uses In DR Congo the leaves of *Sericostachys scandens* collected from the wild are eaten as a vegetable. The leaves are applied as a poultice on wounds and from the bark a medicine for venereal diseases is prepared. In Rwanda and Uganda *Sericostachys scandens* is a key species for honey production from wild flowers in the forest. In Kenya initiation ceremonies are related to the occurrence of flowering, which is there thought to happen only once every 7–8 years.

Botany Much-branched, scandent shrub, with branches up to 30 m long; branches opposite, terete to angular, finely striate, swollen at the nodes. Leaves opposite, simple; petiole 1–2.5 cm long; blade broadly ovate to lanceolate-ovate, 5–15 cm × 3–8 cm, base cuneate to attenuate, apex acuminate, margin entire, almost glabrous to densely tomentose. Inflorescence a broad panicle of spike-like branches up to 8 cm long with sessile flower clusters and persistent bracts up to 6 mm long; each flower cluster consisting of 1 fertile and 2 modified sterile flowers, subtended by 2 bracteoles up to 6 mm long, long pilose in sterile flowers. Fertile flowers bisexual, 5-merous; tepals lanceolate, 4–8 mm long, with pale margins, glabrous to pilose; stamens 3.5–6 mm long, at base fused to a solid disk-like rim and alternating with very small tooth-like staminodes; ovary superior, 1-celled, glabrous, style filiform, up to 3 mm long, stigma capitate. Sterile flowers consisting of up to 12 linear appendages densely furnished with spreading hairs, much accrescent in fruit. Fruit a thin-walled, indehiscent, ovoid-cylindrical capsule 3 mm long, 1-seeded, enclosed by and falling with the persistent

perianth and bracteoles. Seed ovoid, 2.5–3 mm long, shiny brown.

Sericostachys comprises only a single species. It strongly resembles *Clematis* (*Ranunculaceae*) with its climbing habit and the hairy appendages surrounding the fruits. *Sericostachys scandens* can be found flowering year-round and the flowers are much visited by bees. The fruits are dispersed by wind.

Ecology *Sericostachys scandens* usually scrambles over trees and shrubs, often in riverine or lakeside forest, at 700–2600 m altitude.

Genetic resources and breeding *Sericostachys scandens* is widespread and not in danger of genetic erosion.

Prospects *Sericostachys scandens* probably will remain a minor vegetable. Its nutrional and medicinal properties need further investigation. Its possibilities as an ornamental are more promising; in fruit it is strikingly decorative.

Major references Burkill, H.M., 1985; Hauman, L., 1951a; Townsend, C.C., 1985; Townsend, C.C., 1988.

Other references Cavaco, A., 1974; Keay, R.W.J., 1954a; Townsend, C.C., 2000.

Authors P.C.M. Jansen

SESAMUM ALATUM Thonn. ex Schumach.

Protologue Beskr. Guin. pl.: 284 (1827).

Family Pedaliaceae

Chromosome number $2n = 26$

Vernacular names Sesame of the gazelle, sesamum (En). Sésame de gazelle (Fr).

Origin and geographic distribution *Sesamum alatum* is widely distributed in tropical Africa, occurring in dry regions from Senegal to South Africa. In Madagascar, India and occasionally elsewhere it has been introduced. It is sometimes cultivated around villages.

Uses The leaves and young shoots of *Sesamum alatum* are collected from the wild and used as a cooked vegetable, sometimes flavoured with its pounded seeds. The seeds are occasionally cooked separately as a relish or boiled with pumpkin leaves and served with a staple food. The seed produces an edible oil, and is used as an aphrodisiac and to cure diarrhoea and other intestinal disorders. A decoction of the leaves is given to cattle to promote their fertility.

Properties There is no information on the nutritional composition of *Sesamum alatum* leaves, but it is probably comparable to that of *Sesamum indicum* L. (cultivated sesame) leaves, which is per 100 g edible portion: water 85.5 g, energy 188 kJ (45 kcal), protein 3.4 g, fat 0.7 g, carbohydrate 8.6 g, fibre 2.4 g, Ca 77 mg, P 203 mg, riboflavin 0.3 mg. The nutritional composition of dried seeds per 100 g is: water 7.9 g, energy 1733 kJ (414 kcal), protein 10.8 g, fat 18.1 g, carbohydrate (including fibre) 55.2 g, fibre 30.5 g, Ca 432 mg, P 221 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968).

The seed oil has about 5% unsaponifiable matter, consisting of lignans (2-episesalatin 1.4%, sesamin 0.01%, sesamolin 0.01%), sterols (22%) and tocopherols (210–320 mg/kg oil).

Botany Erect annual herb up to 1.5 m tall, with simple or sparsely branched stem, glabrous but with mucilage glands. Leaves opposite, lower ones palmately divided or lobed, upper ones simple; stipules absent; petiole 1–7 cm long; leaflets or lobes of lower leaves lanceolate, central one longest, up to 8 cm × 2 cm, often with undulate margin, blade of upper leaves linear to lanceolate, 3–10 cm long. Flowers solitary in leaf axils, bisexual, zygomorphic, 5-merous; pedicel short, with a nectary at base; calyx campanulate with narrowly triangular lobes c. 3 mm long, densely glandular, deciduous; corolla obliquely campanulate, 2–3 cm long, slightly 2-lipped, pink or purple, inside sometimes red-spotted, pubescent; stamens 4; disk fleshy, conspicuous; ovary superior, hairy, 2-celled, style filiform, stigma 2-lobed. Fruit a narrowly obconical capsule up to 5 cm × 0.7 cm, base gradually narrowed, apex with beak up to 12 mm long, 4-grooved, dehiscing longitudinally, many-seeded. Seeds obconical, c. 2.5 mm × 1.5 mm, with a large, 2–3 mm long wing at apex and 2 shorter wings at base, testa with honeycomb-like structure, pale to dark brown.

Sesamum comprises about 20 species, most of which are indigenous to tropical Africa. *Sesamum alatum* belongs to section *Sesamopteris*, together with *Sesamum triphyllum* Welw. ex Asch., both species having winged seed.

Ecology *Sesamum alatum* occurs in dry savanna and is often common around villages, sometimes tolerated as a weed in fields. It is often found on sandy soils, in river beds, grassland and open bushland, or as a weed in fields, often in cultivated sesame.

Genetic resources and breeding *Sesamum alatum* is widespread and not in danger of genetic erosion. It has been suggested that *Sesamum alatum* is one of the progenitors of the cultivated sesame (*Sesamum indicum*).

Crosses of *Sesamum alatum* and *Sesamum indicum* have given fertile hybrids that may be important in breeding programmes for improved sesame cultivars. For example, attempts have been made to transfer the resistance of *Sesamum alatum* to the phyllody disease (a highly destructive phytoplasma disease of sesame transmitted by a leafhopper) to sesame cultivars. *Sesamum alatum* also proved to be highly resistant to sesame leaf roller and pod borer.

Prospects *Sesamum alatum* will remain a minor vegetable of local importance in drier areas. It may play an important role in breeding programmes of sesame.

Major references Bedigian, D. & van der Maesen, J., 2003; Burkill, H.M., 1997; Busson, F., 1965; Ihlenfeldt, H.-D., 1988.

Other references Baskaran, R.K.M., Mahadevan, N.R., Sridhar, P., Kandasamy, G. & Thangavelu, S., 1990; Bruce, E.A., 1953; Humbert, H., 1971; Kamal-Eldin, A. & Appelqvist, L.A., 1994; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Parani, M., Singh, K.N., Rangasamy, S.R.S. & Ramalingam, R.S., 1996; Reddy, A.R. & Das, V.S.R, 1995; Smartt, J. & Simmonds, N.W. (Editors), 1995; Tredgold, M.H., 1986.

Authors P.C.M. Jansen

SESAMUM ANGOLENSE Welw.

Protologue Apont.: 588 (1859).
Family Pedaliaceae
Chromosome number $2n = 32$
Vernacular names Mlenda (Sw).

Origin and geographic distribution *Sesamum angolense* is found in DR Congo, Rwanda, Burundi, Kenya, Uganda, Tanzania, Malawi, Zambia, Angola, Zimbabwe and Mozambique.

Uses The leaves of *Sesamum angolense* are collected from the wild, wilted and cooked alone or mixed with beans, peas, groundnuts or amaranth, and served with a staple food. They are sometimes sold on local markets. The cooked leaves form a very slimy product. In Malawi *Sesamum angolense* is often eaten with bran porridge and is particularly popular with women; the dish is often given to babies and disabled persons.

A decoction or infusion of the leaves or roots is drunk to counteract vomiting, cough, catarrh, constipation, diarrhoea and poisoning, and applied externally to cure wounds and skin diseases such as measles and sores, and to curtail bleeding after tooth removal. Formerly, in Malawi, the leaves were pounded with water and the liquid poured into the eyes and over the ears, nose and mouth to cure smallpox. In Malawi an infusion of the roots is drunk at the time of labour to hasten delivery. An infusion of the leaves in water is also used as a shampoo to oil and straighten the hair and as a substitute for soap. The leaves can also be dried and stored for later use, either whole or powdered.

Properties There is no information on the nutritional composition of *Sesamum angolense* leaves, but it is probably comparable to that of *Sesamum indicum* L. (cultivated sesame) leaves, which is per 100 g edible portion: water 85.5 g, energy 188 kJ (45 kcal), protein 3.4 g, fat 0.7 g, carbohydrate 8.6 g, fibre 2.4 g, Ca 77 mg, P 203 mg, riboflavin 0.3 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). The seed of *Sesamum angolense* yields 24% of a green fixed oil, which contains 9% of the phenylpropanoid sesamin. Although the yield of oil is little more than half that of commercial sesame, the high sesamin content offers opportunities for developing the oil as a synergist to pyrethrin insecticides. The haemostatic properties of the roots are possibly caused by the presence of iridoid glucosides (sesamoside, phlomiol, pulchelloside-I and 6-β-hydroxy-ipolamide) or the phenylpropanoid glycoside verbascoside.

Botany Erect annual or perennial herb up to 3 m tall, bad smelling, with simple or branched, slightly quadrangular stem. Leaves opposite, simple, without stipules, sessile or with short petiole; blade oblong, elliptical to oblanceolate, 2–11 cm × 0.5–4 cm, base cuneate, apex truncate, retuse or acute and usually mucronate, margin entire, more or less inrolled, glabrescent above, white tomentose and densely glandular below. Flowers solitary in leaf axils, bisexual, zygomorphic, 5-merous; calyx campanulate, with lanceolate lobes up to 1 cm × 2 mm, pubescent, persistent in fruit; corolla obliquely campanulate, up to 7 cm long, 2-lipped, pink, red, purple or pale mauve with deeper markings, pubescent; stamens 4, filaments arising from a band of hairs near the base of the corolla tube; disk annular, regular; ovary superior, white-hairy, 2-celled, style filiform, stigma 2-lobed. Fruit a slightly quadrangular capsule 2–3 cm × 5–7 mm, 4-grooved, gradually narrowed into a flattened short beak, densely pubescent but glabrescent, dehiscing longitudinally, many-seeded. Seeds flattened obconical, c. 2 mm × 1.5 mm, not winged,

faintly rugose.
Sesamum comprises about 20 species, most of which are indigenous to tropical Africa. *Sesamum angolense* belongs to section *Aptera*, characterized by entire leaves and seeds without wings, together with e.g. *Sesamum angustifolium* (Oliv.) Engl., *Sesamum calycinum* Welw. and *Sesamum radiatum* Thonn. ex Hornem. This section is closely related to the genus *Ceratotheca*. *Sesamum angolense* can be recognized easily by its leaves, which are white tomentose below, and its large flowers.

Ecology *Sesamum angolense* is common in grassland, open woodland, roadsides and abandoned fields, on black or red loam soil, at 400–2400 m altitude.

Genetic resources and breeding *Sesamum angolense* is widespread and not in danger of genetic erosion.

Prospects *Sesamum angolense* will remain a minor vegetable, of importance when other vegetables are scarce. Its medicinal properties are promising and deserve more attention, in addition to research on the nutritional composition of the leaves. *Sesamum angolense* with its attractive large flowers frequently visited by bees also has potential as a garden ornamental and bee forage.

Major references Bedigian, D. & van der Maesen, J., 2003; Bruce, E.A., 1953; Ihlenfeldt, H.-D., 1988; Ruffo, C.K., Birnie, A. & Tengnäs, B., 2002; Williamson, J., 1955.

Other references Kokwaro, J.O., 1993; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Potterat, O., Msonthi, J.D. & Hostettmann, K., 1988; Tredgold, M.H., 1986; Watt, J.M. & Breyer-Brandwijk, M.G., 1962.

Authors P.C.M. Jansen

SESAMUM ANGUSTIFOLIUM (Oliv.) Engl.

Protologue Pflanzenw. Ost-Afrikas C: 365 (1895).

Family Pedaliaceae

Chromosome number $2n = 32$

Synonyms *Sesamum calycinum* Welw. var. *angustifolium* (Oliv.) Ihlenf. & Seidenst. (1968).

Vernacular names Wild simsim (En). Mfuta, mlenda mwitu (Sw).

Origin and geographic distribution *Sesamum angustifolium* occurs in Kenya, Uganda and Tanzania, but its distribution area may be larger because it is bordered by that of the closely related and very similar *Sesamum calycinum* Welw., with which it is easily confused.

Uses The leaves and young shoots of *Sesamum angustifolium* (and also those of *Sesamum calycinum*) are mostly collected from the wild. As the cooked leaves are mucilaginous they are chopped and cooked together with other ingredients such as other leaf vegetables (e.g. *Corchorus*), peas and beans to thicken sauces that are eaten with the staple food. The taste is mild to sour and in Uganda it is eaten frequently, but elsewhere it is often considered a famine food. The unpleasant smell of raw chopped leaves mostly disappears with cooking. The leaves and young shoots can be dried and stored for later use.
The seeds produce an edible oil, but they are mostly eaten in a sauce or soup after grinding and heating. In Kenya the plant is fed to cattle, mixed with sweet potatoes to make digestion easier. The mucilage of rubbed leaves in water is used to treat eye troubles, burns, wounds, stomach-ache, diarrhoea in children and to ease labour and delivery. In Tanzania a root decoction is used to treat cough and an infusion of powdered roots is drunk to cure diarrhoea and other intestinal disorders. Crushed leaves are used as a soap substitute, rubbed into the hair when washing it to give it a glossy look, but also to treat baldness. In Tanzania the sticky crushed leaves have been used to trap tsetse flies on cattle, a fresh application giving protection for about 4 hours. The seed oil is used to treat ringworm.

Properties There is no information on the nutritional composition of *Sesamum angustifolium* leaves, but it is probably comparable to that of *Sesamum indicum* L. (cultivated sesame) leaves, which is per 100 g edible portion: water 85.5 g, energy 188 kJ (45 kcal), protein 3.4 g, fat 0.7 g, carbohydrate 8.6 g, fibre 2.4 g, Ca 77 mg, P 203 mg, riboflavin 0.3 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). The seed of *Sesamum angustifolium* yields about 30% oil which is pale to dark yellow and odourless. The oil contains 3.7% unsaponifiable matter, of which 16% lignans (sesangolin 3.2%, sesamin 0.3%, sesamolin 0.2%) and 800 mg tocopherols per kg oil.

Botany Erect or spreading, simple or branched herb up to 2 m tall, with grooved, quadrangular, glabrescent stem. Leaves opposite, simple, without stipules, almost sessile; blade linear-lanceolate, 2–12 cm × 0.1–4 cm, base cuneate, apex acute or rounded, margin entire, undulate or sometimes in lower leaves irregularly toothed, thinly pubescent to gla-

brous above, usually densely glandular below. Flowers solitary in leaf axils, bisexual, zygomorphic, 5-merous; calyx campanulate with lanceolate lobes up to 9 mm long, persistent in fruit; corolla tubular, 2–4 cm long, 2-lipped, pink, red, mauve or purple, often spotted inside, pubescent; stamens 4, filaments arising from a band of hairs in the corolla tube; disk annular; ovary superior, 2-celled, style filiform, stigma 2-lobed. Fruit a narrowly oblong, quadrangular capsule up to 2.5 cm × 4 mm, deeply 4-grooved, apex with a narrow beak up to 3.5 mm long, glabrous to slightly pubescent, dehiscing longitudinally, many-seeded. Seeds c. 1.5 mm × 1 mm, not winged, surface rugose, black.

Sesamum angustifolium belongs to section *Aptera*, together with e.g. *Sesamum angolense* Welw., *Sesamum calycinum* Welw. and *Sesamum radiatum* Thonn. ex Hornem, and opinions differ about its delimitation. The difference between *Sesamum angustifolium* and *Sesamum calycinum* is not always clear. The fruits of *Sesamum calycinum* are usually broader and its seeds usually larger and have a double fringe.

Ecology *Sesamum angustifolium* is common in roadsides, grassland and as a weed in fields, from sea-level up to 2000 m altitude.

Management *Sesamum angustifolium* is mostly collected from the wild, but occasionally cultivated around houses or in fields, and sold at local markets. Propagation is by seed and seedlings are thinned to a spacing of about 20 cm. Young shoots can be harvested about 6 weeks after sowing and if water and soil fertility allow, harvesting can be repeated about 6 times because the plant recovers from the base. When the plant starts flowering and fruiting the shoots become too woody for vegetable use.

Genetic resources and breeding *Sesamum angustifolium* is widespread and not in danger of genetic erosion.

Prospects In East Africa *Sesamum angustifolium* is locally an appreciated vegetable, which is occasionally cultivated but also widely available from the wild. Its nutritional composition and medicinal properties deserve further research. *Sesamum angustifolium* has potential as an attractive garden ornamental.

Major references Grabow-Seidensticker, U., 1988; Ihlenfeldt, H.-D., 1988; Katende, A.B., Ssegawa, P. & Birnie, A., 1999; Maundu, P.M., Ngugi, G.W. & Kabuye, C.H.S., 1999; Ruffo, C.K., Birnie, A. & Tengnäs, B., 2002.

Other references Bedigian, D. & van der Maesen, J., 2003; Burkill, H.M., 1997; Bruce, E.A., 1953; Gelfand, M., Mavi, S., Drummond, R.B. & Ndemera, B., 1985; Kamal-Eldin, A. & Appelqvist, L.A., 1994; Kokwaro, J.O., 1993; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Schippers, R.R., 2000; Sorensen, C., 1993; Tredgold, M.H., 1986; Watt, J.M. & Breyer-Brandwijk, M.G., 1962.

Authors P.C.M. Jansen

SESAMUM RADIATUM Thonn. ex Hornem.

Protologue Enum. pl. hort. hafn., suppl. 2: 12 (1806).

Family Pedaliaceae

Chromosome number $2n = 64$

Vernacular names Black benniseed (En).

Origin and geographic distribution *Sesamum radiatum* is of African origin and was taken into cultivation in Africa at an early date. It occurs wild in West and Central Africa and is cultivated there on a small scale. It does not occur in East and southern Africa (except northern Angola), but is sometimes cultivated and found naturalized in tropical Asia.

Uses Fresh leaves of *Sesamum radiatum* are a popular leafy vegetable. Young shoots are finely cut for use in soups or sauces eaten with porridge. Cooked leaves have a slimy texture. *Sesamum radiatum* is sometimes grown for its seeds. These are consumed whole, toasted or after grinding as paste. An edible oil can be extracted from the seed, but this is rarely done, although the seed may be an adulterant of sesame seed (*Sesamum indicum* L.).

Sesamum radiatum has several medicinal and cosmetic uses. A cold leaf infusion is drunk to

Sesamum radiatum – wild and planted

ease childbirth. A leaf infusion is used as a shampoo and to kill head lice. A mixture of paste from pounded seeds and shea butter and other ingredients is applied as a treatment for rectal prolapse. Filtrate of crushed leaves is drunk to treat metrorrhagia and a leaf maceration is used for bathing for the same purpose. Macerated fresh leafy stems are drunk as an antidote for scorpion stings; they are applied externally to treat sprains.

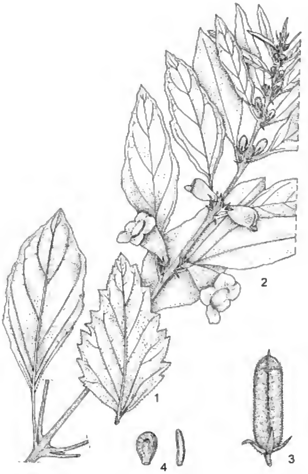
Production and international trade *Sesamum radiatum* is only grown on a small scale, mainly for home consumption.

Properties There is no information on the nutritional composition of *Sesamum radiatum* leaves, but it is probably comparable to that of *Sesamum indicum* leaves, which is per 100 g edible portion: water 85.5 g, energy 188 kJ (45 kcal), protein 3.4 g, fat 0.7 g, carbohydrate 8.6 g, fibre 2.4 g, Ca 77 mg, P 203 mg, riboflavin 0.3 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968).

The seed contains 32.3% oil. The oil is similar in composition to sesame oil; its fatty acid composition is oleic acid 40%, linoleic acid 40%, palmitic acid 10% and stearic acid 7%. The oil contains the phenylpropanoid lignan sesamin (2.4%). This compound showed antioxidant, anti-inflammatory, antihypertensive, cytotoxic (including antitumour) and insecticidal activities.

Adulterations and substitutes Several other *Sesamum* species and *Ceratotheca sesamoides* Endl. are used in similar ways as a potherb and for their edible oily seeds.

Description Erect annual herb up to 120(–150) cm tall; stem simple or branched, glandular pubescent. Leaves opposite or alternate in upper part of plant, simple; stipules absent; petiole up to 2.5 cm long in lower leaves, short in upper leaves; blade lanceolate to ovate or elliptical, 3–10(–12) cm × 1.5–5(–7) cm, cuneate to obtuse at base, acute at apex, coarsely serrate in lower leaves, usually entire in upper leaves, pubescent and densely mealy glandular below. Flowers solitary in leaf axils, bisexual, zygomorphic, 5-merous, with 2 bracts at base, each bract with an axillary, sessile gland; pedicel (2–)3–4(–5) mm long; calyx with narrowly triangular lobes up to 7 mm long, connate at base; corolla obliquely campanulate, 2.5–5 cm long, pubescent, pink to purplish, sometimes white, lower lobe slightly longer than other lobes; stamens 4, inserted near base of corolla tube and included; ovary superior, 2-celled but each cell divided by a false septum almost to



Sesamum radiatum – *1, leaf; 2, flowering branch; 3, fruit; 4, seeds.*
Redrawn and adapted by Achmad Satiri Nurhaman

apex, style long and slender, with 2-lobed stigma. Fruit an oblong-quadrangular capsule 2–3.5 cm long, slightly compressed laterally, pubescent, with a very short beak at apex, often with 2 lateral short protuberances, loculicidally dehiscent, many-seeded. Seeds obovate in outline, compressed laterally, 2.5–3.5 mm × 1.5–2 mm, testa with radial sculptures, black or brown. Seedling with epigeal germination; hypocotyl 1–2 cm long; cotyledons broadly elliptical, up to 1 cm long, entire, leafy.

Other botanical information *Sesamum* comprises about 20 species, most of which are indigenous to tropical Africa. Sometimes small horns can be present on fruits of *Sesamum radiatum*, and in that case confusion is possible with *Ceratotheca sesamoides*. In habit *Sesamum radiatum* resembles *Sesamum indicum*, but it can be distinguished by the testa structure (smooth in the latter species).

Sesamum radiatum and other *Pedaliaceae* are covered with mucilage glands. The mature

secreting glandular hair consists of a head of 4 cap cells, which are attached to a stalk of 1–3 cells. The glands may enable the plant to withstand severe desiccation without tissue death. After contact with water, the outer cell walls of the head cells dissolve, producing an enormous amount of mucilage.

Growth and development *Sesamum radiatum* shows indeterminate growth, so that flowering continues as long as environmental conditions permit, longer than is usual for sesame. In a germplasm evaluation trial in Kadugli, Sudan an accession identified as *Sesamum radiatum* continued growth for 2 months after all other accessions of sesame had senesced and were harvested.

Sesamum radiatum is primarily self-pollinated; the flowers open at dawn, after pollination has occurred. However, under extreme conditions some outcrossing may occur. It takes about 6 weeks from anthesis to fruit maturity. The fruits do not open fully; an angular pocket at the base of the fruit retains some seeds

Ecology *Sesamum radiatum* is adapted to a wide range of habitats, but is most common in savanna. It occupies open localities where few other herbaceous plants grow. It occurs on nutritionally poor sites, growing in gravelly, sandy and rocky localities. It is also a weed and occurs in formerly cultivated fields. It tolerates heat and drought well and continues growth and flowering during the dry season.

Propagation and planting The weight of 1000 seeds is about 2.5 g. Seed may be sown into seedbeds, in seed boxes or directly 2–3 seeds per hole. Germination takes 6–10 days. Seedlings are transplanted at a spacing of approximately 15 cm.

Management *Sesamum radiatum* responds well to fertilizer. For leaf production plants are topped to promote the growth of new basal shoots from which larger leaves can be harvested. Plants in their second year may be pruned to a height of 2–5 cm to encourage new shoot production.

Diseases and pests Phyllody (a mycoplasma disease) and stem fasciation appear in wild *Sesamum* species as well as sesame cultivars. *Cercospora sesami* may cause small black spots with diffuse edges on the leaves and also on the stems and fruits. Caterpillars of hawk moths (*Sphingidae*) may defoliate a plant in a few days. The caterpillars are parasitized by nematodes and flies that kill them before pupation. Larvae of another moth, *Antigastra catalaunalis*, damage the tops of plants. The green vegetable bug *Nezara viridula* feeds on the leaves, causing small brown spots.

Resistance to *Antigastra catalaunalis* (shoot webber), the root-knot nematode *Meloidogyne incognita*, Phytophthora blight, Fusarium wilt, leaf blight and seedling blight in *Sesamum radiatum* has been reported.

Harvesting The first leaves can be harvested 8–10 weeks after sowing. Harvesting at 7–10-day intervals can continue for a period of about 14 weeks. Harvesting for seed is after about 4 months.

Yield In Nigeria a leaf yield of 5–6 t/ha (5–6 kg per 10 m^2 bed) can be expected.

Handling after harvest Leaves harvested in the rainy season may be dried and stored for use during the dry season. They are brought from the field, cleaned and spread out in the sun without prior blanching. After drying they are crushed to powder and stored in bags or plastic containers.

Genetic resources *Sesamum radiatum* is widespread and occurs in various habitats, and is consequently not in danger of genetic erosion. No germplasm collections or breeding programmes are known to exist.

Prospects *Sesamum radiatum* will probably remain of some importance in West Africa as it produces fresh leaves during the dry season.

Major references Bedigian, D., in press; Burkill, H.M., 1997; Busson, F., 1965; Dokosi, O.B., 1969; Gautier-Béguin, D., 1992; Ihlenfeldt, H.-D., 1988; Irvine, F.R., 1969; Neuwinger, H.D., 2000; Stevels, J.M.C., 1990.

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Sources of illustration Stevels, J.M.C., 1990.

Authors D. Bedigian

SESUVIUM PORTULACASTRUM (L.) L.

Protologue Syst. nat., ed. 10: 1058 (1759).

Family Aizoaceae

Chromosome number $2n = 16, 32, 36, 48$

Synonyms *Portulaca portulacastrum* L. (1753).

Vernacular names Seaside purslane, samphire, cenicilla (En). Pourpier de mer, pourpier maritime (Fr). Beldroega da praia (Po).

Origin and geographic distribution *Sesuvium portulacastrum* is widely distributed in the tropics and subtropics on saltwater beaches. It occurs along all coasts of Africa.

Uses *Sesuvium portulacastrum* is occasionally but in many countries eaten as a vegetable, and the leaves have the acidulous flavour of sorrel (*Rumex* spp. and *Oxalis* spp.). Because it is very salty, it needs repeated boiling in fresh water. Several animals graze it (sheep, goats, camels) and it is said to be a favourite food of crabs. In Ghana it is burnt to smoke fish. In Senegal the plant is used as a haemostatic and a decoction is considered the best antidote for stings of venomous fish; it should be applied externally for a long time. The leaves are said to be antiscorbutic. *Sesuvium portulacastrum* is sometimes cultivated as an ornamental and as ground cover to prevent erosion in dune vegetation.

Properties At increasing levels of NaCl in the soil (up to 600 mM), total amino acid and sugar contents of *Sesuvium portulacastrum* decrease while protein, starch, proline and glycinebetaine contents increase. The insect moulting hormone 20-hydroxyecdysone has been isolated from *Sesuvium portulacastrum*.

Botany A suberect, prostrate or creeping, glabrous, succulent perennial herb, up to 30 cm tall, with thick stems rooting at the nodes. Leaves opposite, simple, fleshy; blade oblanceolate, 1–6.5 cm × 0.1–1.5 cm, base gradually narrowing into a petiole, scarious-expanded, stem-clasping and connate with base of opposite leaf, apex rounded, margins entire. Flowers solitary, bisexual, regular, 7–12 mm long; pedicel 3–15 mm long, thickened upwards; tepals 5, persistent in fruit, connate at base into a tube about one third of the length of the lobes, these unequal, triangular, acute, just below the apex each with a fleshy dorsal apiculus 1.5 mm long, green outside, pink to red-purplish inside; stamens many, free, inserted in the mouth of the perianth tube; ovary superior, (2–)3–4-celled, styles (2–)3–4. Fruit a circumscissile capsule with the lid remaining whole, many-seeded. Seeds smooth, black.

Sesuvium comprises about 12 species and is closely related to *Cypselea* and *Trianthema*, together thought to link *Aizoaceae* to *Portulacaceae*; it is sometimes classified in the latter family.

Ecology *Sesuvium portulacastrum* grows on maritime shores at about high water-level, in saline beach-dunes in the littoral, marshes, lagoons and disturbed locations in coastal areas. It is very salt tolerant and a pioneer sand-colonising plant that grows on the upper beach and seaward slope of the frontal dune or beach ridge. It traps and holds wind-blown sand and tends to form small ridges or mounds. It does not survive complete burial under wind-blown sand. It also grows well in more protected littoral locations and it can be included in dune revegetation programmes. Flowering and fruiting is year round. Each flower opens for only a few hours per day.

Management *Sesuvium portulacastrum* can be propagated by seed and by rooted stem cuttings. Plants are preferably planted in well-drained sandy soil, spaced 75–150 cm apart. *Sesuvium portulacastrum* grows in full sun and tolerates acidic and alkaline soils, having also a high drought tolerance. It is a low-maintenance plant, needing no irrigation or fertilizer and serious diseases or pests are not known.

Genetic resources and breeding *Sesuvium portulacastrum* is widespread and not in danger of genetic erosion.

Prospects *Sesuvium portulacastrum* is an interesting vegetable, easy to grow, remaining of value in suitable locations. It is an important pioneer species on sandy beaches in the subtropics and tropics, where its mat-forming growth habit promotes embryonic dune formation.

Major references Bogle, A.L., 1970; Burkill, H.M., 1985; Jeffrey, C., 1961.

Other references Lonard, R.I. & Judd, F.W., 1997; van den Bergh, M.H., 1993; Venkatesalu, V., Kumar, R.R. & Chellappan, K.P., 1994a; Venkatesalu, V., Kumar, R.R. & Chellappan, K.P., 1994b.

Authors P.C.M. Jansen

SMITHIA ELLIOTII Baker f.

Protologue Legum. Trop. Africa 2: 304 (1929).

Family Papilionaceae (Leguminosae - Papilionoideae, Fabaceae)

Origin and geographic distribution *Smithia elliotii* is recorded from Nigeria, Cameroon, DR Congo, Burundi, Ethiopia, Kenya, Uganda, Tanzania, Malawi, Zambia, Mozambique and Madagascar.

Uses In Malawi the leaves of *Smithia elliotii* are cooked and eaten as a side dish. The leaflets are separated from the rachis and cooked with the addition of potash. The cooked product is so slippery that most of it runs back into the dish when a lump of porridge is dipped in; hence it goes a long way. The dish is frequently eaten by women and children and is prepared especially for babies and invalids. Vegetable use has been recorded from DR Congo as well, but no details have been published.

Botany Decumbent herb up to 180 cm long. Leaves alternate, paripinnate with 10–28 leaflets; stipules with a basal extension, up to 3.5 cm long; petiole 2–5 mm long, rachis 1.5–5.5 cm long; leaflets linear-oblong, 3–15 mm × 1–5 mm, base obliquely rounded, apex rounded to acute, apiculate. Inflorescence umbellate, 1–1.5 cm long, dense, up to 12-flowered; bracts early caducous. Flowers bisexual, papilionaceous; calyx c. 1 cm long, covered with yellow bristles; corolla purplish, standard c. 1 cm long. Fruit a pod with 4–7 segments, each segment 2–3 mm long and wide.

Smithia comprises about 30 species, most of them from Asia and Madagascar. *Smithia erubescens* (E.Mey.) Baker f. is restricted to South Africa and Swaziland and records for this species from tropical Africa refer to either *Smithia elliotii* or to *Smithia abyssinica* (A.Rich.) Verdc., an Ethiopian endemic.

Ecology *Smithia elliotii* is found in coarse grassland in glades, along streams and in swamps, sometimes even growing in standing water, at 1150–2700 m altitude.

Management *Smithia elliotii* leaves are collected from the wild, and they are commonly sold in local markets in Malawi. There are no recent records on cultivation.

Genetic resources and breeding The risk of genetic erosion is limited because *Smithia elliotii* is widely distributed and not uncommon.

Prospects *Smithia elliotii* will remain of interest as a vegetable only locally.

Major references Verdcourt, B., 2000a; Williamson, J., 1955.

Other references Burkill, H.M., 1995; Gillett, J.B., Polhill, R.M., Verdcourt, B., Schubert, B.G., Milne-Redhead, E. & Brummitt, R.K., 1971; Thulin, M., 1989.

Authors C.H. Bosch

SOLANECIO BIAFRAE (Oliv. & Hiern) C.Jeffrey

Protologue Kew Bull. 41(4): 922 (1986).

Family Asteraceae (Compositae)

Chromosome number $2n = 20$

Synonyms *Senecio biafrae* Oliv. & Hiern (1877), *Crassocephalum biafrae* (Oliv. & Hiern) S.Moore (1912).

Vernacular names Worowo, bologi (En). Worowo (Fr).

Origin and geographic distribution *Solanecio biafrae* occurs naturally in the forest zone from Guinea to Uganda. It is cultivated on a small scale only, mainly in Nigeria and Cameroon.

Uses Fresh succulent leaves of worowo are used as a leafy vegetable in Sierra Leone, Ghana, Benin, Nigeria, Cameroon and Gabon. They are especially popular in south-western Nigeria. They are usually cooked with pepper, tomato and onions. In such dishes there is no need for meat or fish because of the excellent properties of the vegetable, reflected in the Yoruba proverb 'vegetable soup prepared with worowo does not need meat'. However, fish or meat may be added to the soup. In Sierra Leone, where it is called 'bologi', the leaves are eaten as a steamed vegetable in combination

Solanecio biafrae – *wild*

with okra and fish. They are first steamed in boiling water and later squeezed to remove the mucilage from the leaves. The squeezing is followed by 2–3 rinses with cold water to remove the mucilage as completely as possible. An infusion of the leaves is taken as a drink. Among the Yoruba speaking people of south-western Nigeria, a leaf extract of worowo is used to stop bleeding from cuts or injury and in Sierra Leone and Cameroon a leaf extract is used to treat sore eyes. In Côte d'Ivoire pulped leaves are applied to the breasts as a galactagogue. In Congo worowo is used to treat cough and heart troubles, as a tonic and to relieve rheumatic pain, prurient allergies and localized oedemas. In Congo it also has cultural uses in initiation and funeral rituals and in Yoruba culture it is associated with rituals to ward off smallpox.

Production and international trade Worowo is marketed only locally. There are no records of international trade. This vegetable is becoming quite rare and is therefore several times more expensive than *Amaranthus*, *Celosia* or *Corchorus* leaves.

Properties In south-western Nigeria *Solanecio biafrae* occurs in two distinct types: plants with purple stems and plants with green stems. Leaves of the green-stemmed types contain per 100 g dry matter: crude protein 12.3 g, crude fibre 11.8 g, Ca 342 mg, P 39 mg, Fe 52 mg. Leaves of purple-stemmed types contain per 100 g dry matter: crude protein 11.6 g, crude fibre 10.5 g, Ca 320 mg, P 46 mg, Fe 53 mg (Adebooye, O.C., 2000). The leaves of *Solanecio biafrae* contain small amounts (less than 0.1 g/100 g fresh leaves) of terpenoids, mainly the sesquiterpene germacrene D.

Adulterations and substitutes When worowo is not available, it can be replaced by other leafy vegetables, but they all taste different.

Description Perennial climbing herb, with stem up to 3 m long, strongly branched; branches succulent, glabrous. Leaves alternate, simple or deeply pinnately lobed, more or less succulent; stipules absent; petiole 1–8(–10) cm long; blade triangular to hastate or with up to 3 lobes on each side, 5–15 cm × 3–14 cm, margin sparsely toothed, surface glossy. Inflorescence a narrowly campanulate head 9–12 mm × 3–5 mm, arranged in a terminal, compound, dense corymb; head many-flowered, homogamous; peduncle 5–11 cm long; involucral bracts 4–6. Flowers bisexual, tubular, 5-merous; corolla c. 6 mm long, pale yellow; stamens with fused anthers; ovary inferior, 1-celled, style bifid. Fruit a cylindrical, glabrous achene c. 3 mm long, black when ripe, with pappus consisting of long, white, silky hairs.

Solanecio biafrae – 1, young branch; 2, leaf; 3, flowering branch.
Redrawn and adapted by Iskak Syamsudin

Other botanical information *Solanecio* comprises about 16 species and occurs in tropical Africa, Madagascar and Yemen. It belongs to the tribe *Senecioneae* and seems related to *Gynura*, which is not succulent.

Leaves of *Solanecio angulatus* (Vahl) C.Jeffrey are also collected from the wild and used as a cooked vegetable in DR Congo, but it is mainly used for medicinal purposes. The leaves of *Solanecio angulatus* are usually pinnately lobed and its fruits are hairy.

Growth and development *Solanecio biafrae* is a climber that twines clockwise on woody plants. Profuse branching occurs about 50 cm above the ground causing bushy growth. The stems are very tender and break easily even when handled with care. Flowering takes place in Nigeria in January–February. Worowo continues to grow in the dry season under the moist conditions of cacao plantations.

Ecology *Solanecio biafrae* is an understorey climber in the rainforest zone of West and Central Africa, where average annual rainfall is

about 1500 mm, from sea-level to 1300 m altitude. It strongly responds to water stress by developing shrivelled stems and yellowing of the leaves, and cannot survive under dry conditions. In cultivation provision of shade is essential for good growth. It prefers a moist, well-drained soil rich in organic matter.

Propagation and planting Worowo is generally collected from the wild, but is occasionally cultivated. Seed production is abundant and propagation by seed is possible, but viability tends to be very poor (generally < 2%). Moreover, the seed is difficult to clean because of the pappus. The weight of 1000 seeds is about 0.5 g. Seed should be planted in pervious humid soil under light shade. Germination takes several days. Spontaneous seedlings are sometimes collected for transplanting. For vegetative propagation semi-hard cuttings of 10–15(–30) cm long with 4–6 nodes are used. It is recommended to remove the leaves and tops before planting. Cuttings are planted in moist well-drained soil rich in organic matter and always under a tree or shrub for shade and support. There is no need for a nursery. Plants require a spacing of 1.5 m × 1.5 m to allow for easy management when the crop starts branching profusely.

Management As a climber, worowo requires staking or planting under a horizontal trellis of about 1 m high. In plantations where worowo grows as a weed, cacao trees often serve as live stakes. Farmers purposely retain stands of worowo during cleaning operations. In home gardens the use of wooden poles is recommended. Side shade from hedges or trees is beneficial. In south-western Nigeria mulching is advantageous especially during the dry season. Since worowo quickly forms a dense canopy, weed growth is suppressed and manual weeding is required only once before the canopy closes. During the dry season worowo should be well watered. Farmers often cut back flowering shoots to favour leaf production. The quality of worowo leaves grown in gardens is comparable to those collected from cacao plantations or from the wild.

Diseases and pests No serious diseases in worowo have been reported. In Nigeria some damage is caused by variegated locusts (*Zonocerus variegatus*) during the latter part of the dry season. Severe damage by green aphids (*Aphis fabae*) may occur from January–April, causing young shoots to curl and in extreme cases death of whole plants. Mealy bugs suck the leaves. They are particularly noxious on topped twigs with emerging new shoots.

Harvesting Worowo is harvested throughout the year except during flowering. When properly managed, a stand of worowo can be harvested several times for two years, unless whole plants are harvested by uprooting. Harvesting is done by manually cutting the succulent parts of twigs. The first harvest may take place about 2 months after planting.

Yield The leaf yield of worowo in cultivation is about 7 kg/m² at the first harvest and 40 kg/m² per year. Yields may be larger in the subsequent year if rainfall or irrigation is stable and flowering prevented.

Handling after harvest Harvested leaves and tender shoots are tied into bunches for marketing and are sold fresh. They remain fresh for 3 days if kept in humid conditions. In south-western Nigeria farmers sometimes spread the harvested leaves in open baskets at about 8.00 p.m., exposing them to the cool night temperatures to keep the produce fresh before bringing it to the market.

Genetic resources There is an urgent need to collect and preserve the genetic diversity of worowo. In Nigeria wild stands have been decimated and the species is becoming endangered due to massive exploitation without replacement.

Prospects There is ample scope for improving the cultivation of this crop in Africa. It has long been neglected by research and no breeding or selection programmes of worowo are known. Once good husbandry methods and improved cultivars have been developed, more farmers will be able to incorporate the cultivation of this crop into their cropping systems.

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Other references Jeffrey, C., 1986; Olorode, O., 1974; Raponda-Walker, A. & Sillans, R., 1961.

Sources of illustration Stevels, J.M.C., 1990; van Epenhuijsen, C.W., 1974.

Authors O.C. Adebooye

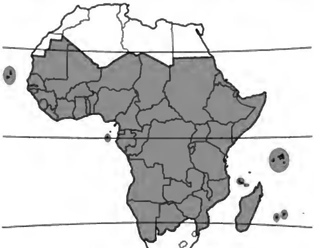
SOLANUM AETHIOPICUM L.

Protologue Cent. pl. II: 10 (1756).
Family Solanaceae
Chromosome number $2n = 24$
Synonyms *Solanum gilo* Raddi (1820), *Solanum incanum* auct. non L.

Vernacular names African eggplant, garden egg, scarlet eggplant, bitter tomato (En). Aubergine africaine, aubergine écarlate, tomate amère, djakattou (Fr). Jiló, jagatú tunga (Po). Ngogwe, nyanya chungu (Sw).

Origin and geographic distribution *Solanum aethiopicum* was domesticated from the wild *Solanum anguivi* Lam., via the semi-domesticated *Solanum distichum* Schumach. & Thonn. Both are found throughout tropical Africa, *Solanum anguivi* in disturbed vegetation and *Solanum distichum* in gardens. *Solanum aethiopicum* is grown throughout tropical Africa and South America (mainly Brazil), and occasionally elsewhere, e.g. in southernmost France and Italy. It is one of the leading vegetables in tropical Africa. In the humid zone of West Africa it is mainly grown for its immature fruit (garden egg), in the savanna area frequently for both its leaves and immature fruits (often called 'djakattou'), and in East Africa, especially Uganda, mainly as a leaf vegetable (called 'nakati').

Uses The immature fruits of *Solanum aethiopicum* are used as cooked vegetables in stews, and sometimes eaten raw. The leaves and shoots are used as a cooked vegetable. They are picked from the same plants that provide the fruit vegetable or from special leafy cultivars. Fruits of bitter cultivars are used as medicine in many African countries. Medicinal applications include the use of roots and fruits as a carminative and sedative, and to treat colic and high blood pressure; leaf juice as a sedative to treat uterine complaints; an alcoholic extract of leaves as a sedative, antiemetic and to treat tetanus after abortion; and crushed and macerated fruits as an enema. Igbo people in south-eastern Nigeria traditionally welcome visitors into the family house by offering fruits. *Solanum aethiopicum* is sometimes cultivated as an ornamental. Some cultivars (Aculeatum Group) are occasionally used as a rootstock for tomato and eggplant.



Solanum aethiopicum – planted

Production and international trade African eggplant is one of the most commonly consumed fruit vegetables in tropical Africa, in quantity and value probably the third, after tomato and onion, and before okra. Reliable statistics for sub-Saharan Africa are not available. A rough estimate for a few countries indicates an annual fruit production of 8000 t in Senegal, 60,000 t in Côte d'Ivoire and 4500 t in Burkina Faso. Commercial production to supply cities is increasing, as is export to Europe, e.g. from Uganda, Côte d'Ivoire and Senegal. Small-scale growers account for at least 80% of the total production. Leaves of *Solanum aethiopicum* are especially important in south-eastern Nigeria, Cameroon and Uganda. It is the most popular leafy vegetable of the market in Kampala. Bitter *Solanum aethiopicum* fruits, called 'jiló', are important as a market vegetable in tropical Brazil, where at least 7000 ha are cultivated.

Properties *Solanum aethiopicum* fruits contain per 100 g edible portion: water 90.6 g, energy 135 kJ (32 kcal), protein 1.5 g, fat 0.1 g, carbohydrate 7.2 g, fibre 2.0 g, Ca 28 mg, P 47 mg, Fe 1.5 mg, β-carotene 0.35 mg, thiamin 0.07 mg, riboflavin 0.06 mg, niacin 0.8 mg, ascorbic acid 8 mg. The composition is comparable with that of eggplant. The composition of fresh leaves per 100 g edible portion is given as: water 82.1 g, energy 215 kJ (51 kcal), protein 4.8 g, fat 0.3 g, carbohydrate 10.3 g, fibre 2.4 g, Ca 523 mg, P 94 mg, Fe 6.0 mg, β-carotene 6.40 mg, thiamin 0.23 mg, riboflavin 0.44 mg, niacin 1.8 mg, ascorbic acid 67 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). This composition is within the range of other dark-green leafy vegetables.

Betulin and sterolin (sitosterol glucoside) have been isolated from the fruits and several sesquiterpenoids from the roots. Among these compounds are lubimin and epilubimin, which have antifungal activity. The leaves contain

oxalate and alkaloids, e.g. solasodine, which has glycocorticoid effects. Their concentration is reduced by cooking. The characteristic bitter taste has been attributed to furostanol glycosides.

Adulterations and substitutes In dishes African eggplant fruits can be replaced by eggplant (*Solanum melongena* L.). The leaves can be replaced by other *Solanum* leafy vegetables, mainly *Solanum americanum* Mill., *Solanum scabrum* Mill. and *Solanum villosum* Mill.

Description Shrub to perennial or annual herb, up to 200 cm tall, often much-branched; root system extending both vertically and laterally; branches and leaves with or without prickles and stellate hairs. Leaves alternate, simple; stipules absent; petiole up to 11 cm long; blade broadly ovate, (6–)12–30 cm × (4–)7–21 cm, obtuse or cordate at base, acute to obtuse at apex, slightly to deeply lobed at margin, pinnately veined; upper leaves smaller, narrower, less lobed and often subopposite. Inflorescence a lateral, racemose cyme, up to 5(–12)-flowered; peduncle often short or even absent, rachis short to long. Flowers bisexual, regular, (4–)5–8(–10)-merous; pedicel (2–)4–12(–15) mm long, up to 27 mm long in fruit; calyx campanulate, lobes 4–10 mm long; corolla stellate, 6–15 mm long, white, sometimes pale purple; stamens inserted near the base of the corolla tube and alternate with corolla lobes, filaments short and thick, anthers connivent, yellow, opening by terminal pores; ovary superior, 2–6-celled, style as long as or slightly longer than stamens, stigma small, obtuse. Fruit a globose to depressed globose, ellipsoid, ovoid or fusiform berry 1–6 cm long, smooth to grooved, red or orange, usually many-seeded. Seeds lenticular to reniform, flattened, 2–5 mm in diameter, pale brown or yellow. Seedling with epigeal germination; cotyledons thin, leafy.

Solanum aethiopicum – 1, flowering branch; 2, flower; 3, different fruit types; 4, fruit in cross section; 5, seed.
Redrawn and adapted by M.M. Spitteler

Other botanical information The genus *Solanum* comprises over 1000 species and is almost cosmopolitan, with at least 100 indigenous African species. *Solanum aethiopicum* belongs to subgenus *Leptostemonum* section *Oliganthes*, which comprises about 45 species. Four cultivar-groups are recognized within *Solanum aethiopicum*, three of which are important for Africa:

- Gilo Group. Mature leaves covered with stellate hairs, generally not prickly; fruit subglobose to ellipsoid, 2.5–12 cm long. The fruits are consumed. This is the most important cultivar-group, which includes cultivars with smooth fruits that are popular in West and East Africa, and cultivars with more or less strongly ribbed fruits. Depending on the location, preference is given to cultivars with pure white, creamy white, pale green, dark green, brown or purple fruits, or cultivars with fruits striped in two or more colours. Cultivars of Gilo Group are grown throughout tropical Africa in the more humid areas.
- Kumba Group. Mature leaves glabrous apart from minute glandular hairs, not prickly; fruit depressed globose, deeply furrowed, frequently multilocular, 5–10(–15) cm broad. The fruits are consumed, as well as occasionally the leaves. Locally the same plants are used for fruits and leaves, whereas other cultivars are only used as a leafy vegetable. Cultivars of Kumba Group are mainly found in hot, semi-arid regions of the Sahel. They are frequently referred to as 'djakattou', 'djakhattou' or 'jakhatou' in francophone countries, but these names can also refer to cultivars of Gilo Group.
- Shum Group. Mature leaves glabrous apart from minute glandular hairs, not prickly; fruit subglobose, 1–3 cm in diameter. It is

mainly a leafy vegetable, and occasionally the ripe fruits are also consumed. It is most widespread in Central Africa, popular in Cameroon and Nigeria and still more so in Uganda where it is called 'nakati'. It is mainly found in warm, high-rainfall areas or under irrigation.

– Aculeatum Group. Stems and leaves prickly, mature leaves covered with stellate hairs; fruit subglobose, furrowed, 3–8 cm in diameter. It is not eaten, mainly cultivated as an ornamental or as rootstock for tomato or eggplant, but not cultivated in Africa.

Intermediate forms between the three African cultivar-groups or between *Solanum aethiopicum* and its wild ancestor *Solanum anguivi* occur. Forms that do not fit in any of the cultivar-groups occur in humid regions of south-western Congo and northern Angola. These are shrublike with sweet fruits having the size of Gilo Group but hollow inside; their leaves are eaten. Further investigations are needed into these cultivars.

Plants of these four cultivar-groups can be crossed mutually as well as with *Solanum anguivi* and *Solanum distichum* to produce fully fertile hybrids, and therefore might be considered as a single biological species. The non-prickly semi-domesticated *Solanum distichum* may well be treated as a cultivar-group of the prickly wild progenitor *Solanum anguivi*.

Growth and development Germination is epigeal, after which the cotyledons expand and the first true leaves form a rosette. New leaves rapidly increase in size and flowering starts (40–)70–100 days after sowing. As the first flowers are initiated, branching and subsequent production of smaller leaves occurs. Most cultivars of Kumba Group in dry hot savanna areas have a shorter growth cycle and flower earlier. Unlike *Solanum melongena*, all flowers are functionally bisexual and can set fruit. They are bee-pollinated, mainly by the genera *Exomalopsis* and *Apis*. Growth and flowering may continue indefinitely, but are suppressed once sufficient fruits have set. The small fruits of Shum Group ripen rapidly, turning red; they are eaten by birds, which disperse the seeds. The much larger fruits of Gilo Group and Kumba Group ripen more slowly and stay firm even when red or yellow, and can be stored for weeks or even months. In the dry season, plants may become dormant and appear to be dead, but can revive in the next rainy season, although they are then not very productive.

Ecology *Solanum aethiopicum* Gilo Group thrives in full sun in woodland savanna on fairly deep and well-drained soils with pH 5.5–6.8, and in temperatures of 25–35°C during the day and 20–27°C at night. Kumba Group grows in hotter conditions (up to 45°C day temperature) with air humidity sometimes as low as 20%, especially if irrigated. Shum Group thrives under warm, humid conditions. It will drop its leaves when it gets dry. In Uganda it is grown in swamps during the dry season. None of these cultivar-groups survive cold or very wet conditions. Waterlogging is not tolerated. Some tolerance of irrigation-induced salinity is reported from Senegal.

Propagation and planting Seeds should be taken from fully ripe fruits, washed, and then dried on cloth or paper. They should not be exposed to direct sunlight. Seeds stored dry and cool are viable for years. Seeds also store well inside air-dried fruits, which is the traditional form of seed storage by farmers. The 1000-seed weight is 2–4 g. Germination takes 5–9 days for Gilo Group and Shum Group, but only 3–5 days for Kumba Group, although the latter may show seed dormancy and tends to have few seeds per fruit. Seeds are sown in sandy soil in nursery beds or boxes. Seedlings are transplanted to the field after 30–35 days, when they have 5–7 leaves and are 15–20 cm tall. Plants of Kumba Group grown in dry savanna regions are often spaced at 1 m × 1 m, whereas those of Gilo Group can be spaced at 50–100 cm in the row and 75–100 cm between rows, depending on the cultivar. They can be grown either on flat land or on ridges. The cultivation of Shum Group is rather different. Cultivars of the latter cultivar-group are grown for their young shoots, which are frequently harvested, and the crop can thus be spaced at 20–30 cm in the row and 60–75 cm between rows. An alternative is to broadcast seeds of Shum Group, whereby thinned plants are used as the first harvest. Seed is sometimes broadcast together with amaranths (*Amaranthus* spp.) and spider plant (*Cleome gynandra* L.), where the latter two crops are harvested early by uprooting and the plants of *Solanum aethiopicum* Shum Group remain.

Management Manual preparation of the soil and hand weeding are sufficient, but large-scale production in Senegal necessitates mechanized soil preparation. Plants do not need staking. If possible, NPK 15–15–15 or 10–10–20 fertilizer may be applied at 150 kg/ha 10 days after transplanting and at 50 kg/ha at first flowering, and then at monthly intervals.

Soluble fertilizers may be fed by drip irrigation. Farm or poultry manure can be applied at a rate of 10–20 t/ha. Plants grown as leaf vegetables (Kumba and Shum Groups) require extra nitrogen to be applied as top dressing at a rate of 50 kg/ha NPK 15–15–15 every two weeks. In the dry season, the crop needs about 5 mm water per day; irrigation twice per week is appropriate. Plants of Shum Group especially need a regular water supply. The growing season of Gilo Group and Kumba Group is extended when irrigation is applied during dry spells and towards the end of the rainy season. In addition, the fruit quality can be much improved by maintaining adequate soil moisture.

Diseases and pests *Solanum aethiopicum* is susceptible to several diseases and pest, although much less than eggplant. The most serious soil-borne diseases are wilt caused by *Ralstonia solanacearum*, collar rot and wilting caused by *Sclerotium rolfsii* and *Verticillium dahliae*, and root-knot nematodes (*Meloidogyne* spp.). These soil-borne diseases and pests can be controlled by crop rotation, e.g. with cereals or other starch crops or with amaranth, groundnut or onion, adequate drainage and a good soil structure. Root-knot nematodes are particularly problematic in areas where vegetables are grown year-round and unless crop rotation is taken seriously, production of African eggplant fruits, tomatoes and capsicums may not be economic. A serious disease, e.g. in Côte d'Ivoire, is *Stemphylium floridanum*; it causes small brown angular leaf spots causing a devastating defoliation. In Tanzania the chilli veinal mosaic virus (ChiVMV) spread by the green peach aphid (*Myzus persicae*) caused considerable damage. Spider mites (*Hemitarsonemus* and *Tetranychus*) are a serious problem in drier regions; acaricide sprays can control them. Other serious pests include grasshoppers (*Zonocerus* sp.), fruit and flower borers (*Leucinodes* and *Scrobipalpa*), leaf hopper (*Jacobiasca lybica*) and caterpillars (*Selepa docilis*). In Uganda the leaves of Shum Group are sometimes eaten by monkeys.

Harvesting The fruits are collected when full sized but still immature; some sweet cultivars are harvested when the fruit colour changes to orange but at the stage when seeds are still immature and soft. The fruits are picked once per week. It is important to continue harvesting fruits even when the market is slack. Fruits that are left on the plant will change colour from pure white to creamy white or pale yellow, fill with seeds, and become less palatable. They will also hamper the development of new fruits. Leaves of Kumba Group are picked from young plants before flowering. Shoots with several leaves and flower buds of Shum Group are picked repeatedly throughout the wet season. Ratoon cropping whereby the main shoots are harvested and allowing new shoots to develop is practised frequently for Shum Group and less often for Kumba Group. This process can be repeated up to six times, as long as there is adequate irrigation and a top dressing with nitrogen is applied. Alternatively, Shum Group plants are uprooted when they are 40–50 cm tall when the first flowers tend to open. They are marketed as young plants with their roots attached. Irrigated crops may be harvested year-round.

Yield The preferred weight for fruits of Gilo Group and Kumba Group is 30–40 g. One plant may produce from 500 g to about 8 kg of fruits, depending on the cultivar and growing conditions. Without irrigation, yields are 5–8 t/ha, and with irrigation 12–20 t/ha. Improved cultivars grown under favourable conditions may yield 50–80 t/ha. Improved cultivars of 'jiló' in Brazil yield 20–30 t of marketable fruits. Fruits of Kumba Group have mean weights of 70–120 g, sometimes even over 200 g; yield is 10–20 t/ha. Under good management, farmers growing cultivars of Shum Group can get up to 75 leaf bundles of 30 kg each per 100 m^2. This means that the crop has a yield potential of 225 t/ha. The average leaf yield during the dry season for a once-over harvest, however, is only 30 t/ha.

Handling after harvest Fruits free of rot or damage can be transported long distances, and stored for several days or even weeks under well-ventilated conditions. Provided that fruits are of good quality, standardization is not necessary; market women often mix different batches of fruits to make an attractive display. During periods of shortage, the market pays higher prices for small fruits because there are more of them per unit of weight whereas during periods of oversupply, larger fruits are appreciated. Mixtures of small and large fruits are common, but not mixtures of fruits with different colour. However, fruits for export are sorted and graded after collection from local markets, and then stored in cold rooms. Fruits and leaves are not normally processed or preserved for long periods. Fresh leaves are taken immediately to the market. The roots of uprooted young plants of Shum Group are washed and left on the plant, which helps to keep the crop fresh at the market

when left standing in water. Shoots should preferably be harvested early in the morning or late in the afternoon. The product should be dry during transport and be dipped in cold water on arrival at the market to reabsorb enough moisture to retain its fresh appearance. The leaves can be sun dried and ground into powder for use in soups during the off-season. Ripe fruits of Shum Group are collected and dried in a similar way to those of *Solanum anguivi*. Fruits are dried and ground into powder for use as a medicine against high blood pressure.

Genetic resources A wealth of genetic diversity is maintained by small-scale farmers throughout Africa. Little work has yet been done on the characterization of the genetic resources of *Solanum aethiopicum* and allied species, however, in particular with respect to disease and pest resistance. The large-scale commercialization of a few cultivars, such as 'Sodefel' (Gilo Group) in Côte d'Ivoire and 'Soxna' (Kumba Group) in Senegal, often in monoculture, has led to the disappearance of some local cultivars but many local landraces can still be found throughout the African continent. Variation in Kumba Group is less than in Gilo Group, possibly due to less cross-pollination in the former. Extensive collections of genetic resources were made under the aegis of International Plant Genetic Resources Institute (IPGRI) from 1981–1986. In 2001, efforts were started to regenerate and evaluate the collections as part of the EGGNET project, an international project for management of the genetic resources of eggplant. A rich germplasm collection is held at INRA in Montfavet, France. A collection is kept at AVRDC in Arusha, Tanzania, and plant breeders in Ghana, Côte d'Ivoire, Nigeria, Senegal and elsewhere in Africa also maintain some accessions.

Breeding Although small-scale farmers have selected many diverse cultivars of *Solanum aethiopicum* and germplasm collections exist, little breeding has been undertaken. Selection criteria are consumers' preference for fruit size, form, colour and taste (sweet or bitter), skin toughness, shelf life, as well as yield potential, disease resistance, earliness and duration of harvest season, plant architecture and fruit location, and for Shum Group ease of leaf harvest. In Senegal, mite-resistant very hairy cultivars of Kumba Group have been bred. Resistance to nematodes and insects, such as flower borers, is urgently needed. Tolerance or resistance to various pests and diseases is being sought amongst wild relatives of *Solanum aethiopicum*, and more especially *Solanum melongena*, and crosses between these two and other species have produced many hybrids, some of which are fertile. In Brazil, crosses of local cultivars of Gilo Group with *Solanum melongena* were more successful when the latter was used as female parent; the F_1 was self-sterile but could be backcrossed with plants of Gilo Group. For breeding purposes, flowers must be bagged to prevent cross-pollination, and must be emasculated to prevent self-pollination. Molecular markers have revealed relatively little diversity within *Solanum aethiopicum* or its immediate progenitors, although morphological diversity and its inheritance have been studied intensively; wild-type characters such as prickles, hairs and long racemose cymes are often dominant. The Crops Research Institute in Ghana, jointly with the Natural Resources Institute (United Kingdom), selected 'Dwomo', the fruits of which have the shape and size of an egg. 'Dwomo' was crossed with *Solanum anguivi* and some promising high-yielding cultivars were selected. Technisem Seed Company in Senegal commercializes improved African eggplant cultivars. Three popular cultivars of Kumba Group are 'Ndrowa' (flat ribbed green-yellow fruits of 70–80 g, diameter 5 cm, with a mild taste, plant height 60–100 cm, harvestable 50–70 days after planting during 3–4 months, yield potential 25 t/ha, resistant to mites), 'Ngalam' (flat strongly ribbed pale green to white fruits of 120–180 g, diameter 7 cm, slightly bitter taste, plant height 60 cm, harvestable 50–60 days after planting during 6 weeks, yield potential 10 fruits per plant, resistant to mites), and 'Jaxatu Soxna' (flat ribbed pale green to white fruits of 40–50 g, diameter 5–6 cm, bitter taste, plant height 50 cm, harvestable 40–60 days after planting during 6 weeks, yield 20–25 fruits per plant or 30 t/ha, or used as leafy vegetable, resistant to mites, drought, high rainfall and high temperatures). In Japan 'Iizuka' of Aculeatum Group was selected as a rootstock for tomato and eggplant in protected cultivation because of its resistance to wilt.

Prospects All three cultivar-groups Gilo, Kumba and Shum are important vegetables in tropical Africa. As the fruits can be easily stored and transported, they are increasingly important products for the urban markets. Hitherto, *Solanum aethiopicum* has been rather neglected in research and breeding, except in breeding programmes for *Solanum*

melongena. With more attention to breeding, agronomy and crop protection (IPM-research) in a cooperative effort by the public and private sector, its potential as a market vegetable can be further developed. Cultivars are needed for different ecological areas and consumer preferences in taste and degree of bitterness, and with resistances, e.g. to *Stemphylium*. The popularity of improved cultivars has led to increased risk of genetic erosion in the local cultivars, making the need for germplasm collections more urgent.

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Sources of illustration Stevels, J.M.C., 1990.

Authors R.N. Lester & A. Seck

SOLANUM AMERICANUM Mill.

Protologue Gard. dict. ed. 8: Solanum No 5 (1768).

Family Solanaceae

Chromosome number $2n = 24$

Synonyms *Solanum nodiflorum* Jacq. (1789), *Solanum nigrum* auct. non L.

Vernacular names Glossy nightshade (En). Morelle noire (Fr). Erva moura, maria pretinha, pimenta de galinha, erva de bicho (Po). Mnavu mchungu (Sw).

Origin and geographic distribution *Solanum americanum* is widespread, found throughout the tropics and subtropics, often in disturbed localities. Its closest relatives are found in South America and this might be the origin. However, the original range cannot be traced from the earliest collections and a few authors have speculated that the species originates from southern Europe and others that it originates from Australia.

Solanum americanum is recorded for many countries of tropical Africa. Unfortunately the Swahili name 'mnavu' and other local names refer to various species of the section *Solanum*. In Tanzania it is called 'mnavu mchungu' meaning bitter nightshade, but *Solanum americanum* is often only slightly bitter. It is reported as a cultivated leafy vegetable from Sierra Leone, the lowlands of Ethiopia, Kenya, Uganda, Tanzania, Seychelles and Mauritius. It is a popular wild pot herb in Côte d'Ivoire and Cameroon, and in eastern Zimbabwe and Mozambique the leaves are also eaten as a vegetable.

Uses The shoots and younger leaves of *Solanum americanum* are boiled as a leafy vegetable. Depending on the bitterness, the cooking water is refreshed. This is done especially for children. Elderly people appreciate a higher degree of bitterness and will therefore leave the flowers and young fruits, whereas people who object to the bitter taste remove them. To further reduce the bitterness, the leaves are served together with cooked amaranth, either separately or as a mixture. In Uganda, the leaves are steamed and the juice is collected and used in soups, so that the nutrients are

Solanum americanum – wild and planted

fully utilized.

Several other uses are reported for *Solanum americanum*, but this information may concern related species. It is believed that leaves cooked with milk, groundnut or sesame (*Sesamum indicum* L.) protect children from diseases associated with malnutrition. In Tanzania the juice extracted from the leaves is used to relieve chronic conjunctivitis and related inflammations. In Cameroon pounded leaves are used to treat sores. In Sierra Leone, people with heart pains use the leaves raw. In Nigeria fruits are used to treat worms in chicken; the fruits are soaked in water and the mixture is given to chicken to drink. In Brazil the leaves are used to treat skin problems. In most regions, *Solanum americanum* fruits are considered inedible but Kipsigis children in Kenya eat the ripe fruits and also in the border region between south-eastern Zimbabwe and Mozambique the sweet fruits of local varieties are much appreciated.

Production and international trade Even though *Solanum americanum* can be found in many countries, its utilization is often limited to collection from the wild or cultivation in home gardens. Commercial production occurs occasionally in coastal lowlands and especially in the Indian Ocean islands. Its importance, compared with other species within the section *Solanum* such as *Solanum scabrum* Mill. and *Solanum villosum* Mill., is limited. No reliable statistics on production or trade are available.

Properties The composition of *Solanum americanum* leaves is probably comparable to other dark-green leafy vegetables. The cooking water is sometimes replaced to reduce the bitter taste of some varieties and especially when leaves are collected from the wild. The bitterness is associated with a high content of the glycoalkaloid solanine, which is found throughout the plant with the highest concentration in the unripe fruits. In the leaves the concentration increases with age. Solanine is poisonous and only partially soluble in water. Eating a large amount of this vegetable has been associated with diarrhoea and cardiac arrest. Other alkaloids isolated from *Solanum americanum* are the steroids solasodine and diosgenin, with the highest concentration found in green fruits.

Adulterations and substitutes In dishes *Solanum americanum* can be replaced by other species of the section *Solanum*, e.g. *Solanum scabrum* or *Solanum villosum*.

Description Annual or short-lived perennial herb, erect and widely spreading, up to 150 cm tall, unarmed; stem rounded or narrowly winged, sometimes warty, glabrous or sparsely pubescent, young stem sometimes covered with curved, simple hairs. Leaves arranged spirally to almost opposite, simple; stipules absent; petiole 1–9 cm long; blade ovate to lanceolate, up to 14(–16) cm × 7(–12) cm, cuneate to truncate at base and decurrent along the petiole, acute to acuminate at apex, entire to toothed, glabrous or sparsely pubescent. Inflorescence an extra-axillary, umbel-like cyme, 3–10-flowered; peduncle 0.5–2.5 cm long, elongating up to 4 cm in fruit. Flowers bisexual, regular, 5-merous; pedicel 5–10 mm long, becoming nodding; calyx cup-shaped, 1.5–2 mm in diameter, lobes ovate to oblong, reflexed in fruit; corolla deeply stellate, 5–9 mm in diameter, white or flushed purple with basal yellow-green star, lobes ovate-oblong, c. 3 mm long; stamens inserted on corolla throat, filaments 0.5–2 mm long, with hairs on inner side, anthers connivent, 1.5–2 mm long, opening by terminal pores; ovary superior, globose, c. 1 mm in diameter, style 2.5–4 mm long, hairy in the lower part, stigma capitate, pale green. Fruit a globose berry 4–8(–10) mm in diameter,

Solanum americanum – 1, flowering branch; 2, inflorescence; 3, fruiting branch.
Redrawn and adapted by Achmad Satiri Nurhaman

from green turning to glossy purplish black at maturity, rarely dark green, many-seeded. Seeds discoid, 1–1.5(–2) mm long, creamy coloured, often tinged with purple. Seedling with epigeal germination.

Other botanical information *Solanum americanum* belongs to the subgenus *Solanum* and section *Solanum*, formerly known as section *Maurella*, or section or subsection *Morella*. Currently about 30 species are included in this section of which 10–12 are known to occur in Africa. Research is still needed to better understand the species within section *Solanum* and their diversity. The diversity within *Solanum americanum* is considerable and a thorough revision of this species may well reveal that several taxa are involved, especially when including material from other continents. In Africa the name *Solanum nigrum* is often used for almost all species of section *Solanum* with blackish fruits, including *Solanum americanum*. The confusion is aggravated by the use of vernacular names that refer to several species of this group. *Solanum americanum* is often confused with *Solanum scabrum*, but more robust stems, larger rounded leaves and larger fruits distinguish the latter.

Growth and development After emergence of the seedling, growth is fast. Flowering starts about two months after germination. *Solanum americanum* is normally self-pollinating, but cross-pollination is possible by insects, mainly bees and syrphid flies. The plant continues to develop new flowers for several months. The fruits drop with the pedicel when fully ripe. They are eaten by birds, which disperse the seeds.

Ecology *Solanum americanum* is mainly found at low altitudes, often in coastal areas or near great lakes, e.g. Lake Victoria. Records from high altitudes may require further verification. It occurs mainly in humid areas on various soil types, in weedy plant communities in the open or in lightly shaded localities e.g. under trees. In semi-arid regions it is mostly found near a water source or as a weed in irrigated fields. It does not tolerate drought.

Propagation and planting *Solanum americanum* is normally propagated by seed. The 1000-seed weight is about 0.5 g. The Giriama people in Kenya, however, propagate it by stem cuttings, selecting strong stems with or without leaves at the top for a new planting. Subsistence farmers sow seeds in pockets of up to 10 seeds at the beginning of the rainy season, as a sole crop or intercropped with other crops. For commercial purposes, seedlings for transplanting are produced in nurseries. The soil is loosened and enriched with decomposed manure in combination with wood ash. The seeds, in most cases mixed with sand or ash, are dispersed evenly over the soil surface or sown in rows and then mulched with grasses to prevent moisture loss from the soil. Transplanting may take place when the seedlings are about 15 cm tall, whereby only strong plants should be selected. The recommended spacing in pure stands is 30 cm × 30 cm, which could be reduced to 20 cm × 30 cm during the dry season. Spacing is normally wider during the rainy season to allow for sufficient air circulation, thus avoiding diseases. The spacing also depends on the size of the harvested shoots. When harvesting short shoots once per week, the planting density should be closer, while for harvesting larger shoots the spacing should be wider. In mixed plantings, the spacing depends on the other crops.

Management In cultivation *Solanum americanum* requires a fairly large amount of nutrients. Incorporating well-decomposed farmyard manure or compost into the soil prior to planting is recommended. When this is not available, compound fertilizers, for example NPK 20–10–10, may be used. Commercial farmers may apply nitrogen fertilizers as top dressings in the form of foliar sprays. Weeding and watering during dry periods are applied when needed.

Diseases and pests The leaf fungus *Cladosporium oxysporum* and a yellow vein virus were observed to attack *Solanum americanum* in Nigeria. The species has been reported to be resistant to bacterial wilt but is susceptible to wilt caused by *Verticillium dahliae*. Black aphids, millipedes and snails have been reported as pests in Kenya, and variegated locust (*Zonocerus variegatus*), aphids and beetles (*Epilachna hirta*) in Nigeria. Farmers spread ash on the leaves to control insects, although various chemical pesticides are also used.

Harvesting Leaves and stem tops are collected from plants in the wild, or from fields during the rainy season. Harvesting is normally done in the early morning. The main shoot or side shoots are plucked before flowering, leaving at least 5 cm of stem for the production of new side shoots. This method allows the farmer to harvest 6–8 times from the same plant. The farmer may select some superior plants which are not harvested but left for seed production.

Yield Although no accurate records are available, the yield of *Solanum americanum* is probably comparable to that of *Solanum villosum* and *Solanum tarderemotum* Bitter since the plant structure and size, and the harvesting method are comparable. The yield can therefore be estimated at 10–20 t/ha, but with adequate management up to 50 t/ha would be feasible.

Handling after harvest The shoots are very tender and therefore highly perishable. The produce is transported in jute bags and, where possible, sold on the same day. Once they arrive at the market, traders sprinkle the leaves with water to keep them fresh. When the product has to be kept for a longer period, it is covered with plastic or banana leaves to protect it from drying.

Genetic resources No specific germplasm collection of *Solanum americanum* is known to exist in Africa, but some accessions of the section *Solanum* are present in genebanks in Kenya, Tanzania and Zimbabwe. Correct identification of the accessions, however, is problematic. A large collection of *Solanum americanum* germplasm is present in the *Solanum* collection of the Botanical and Experimental Garden of Nijmegen University (Netherlands).

Prospects *Solanum americanum* is a potentially important leafy vegetable for the lowlands. Investigations are needed to reduce its alkaloid content, particularly of solanine, to make it safe and more palatable to consumers. Further research is needed into agronomic aspects, pest management and storage. There is also a need to develop appropriate cultivars to give farmers access to reliable sources of seed.

Major references Bukenya, Z.R. & Carasco, J.F., 1999; Chweya, J.A. & Eyzaguirre, P.B., 1999; Edmonds, J.M. & Chweya, J.A., 1997; El Guèye, H.F., 1977; Schippers, R.R., 2000; Siemonsma, J.S. & Jansen, P.C.M., 1993; van Epenhuijsen, C.W., 1974; West, C.E., Pepping, F. & Temaliwa, C.R. (Editors), 1988.

Other references Edmonds, J.M., 1972; Edmonds, J.M., 1977; Henderson, R.J.F., 1974; Hunziker, A.T., 2001; Matlhare, T., Tsamekang, E., Taylor, F.W., Oagile, O. & Modise, D.M., 1999; Nee, M., 1999; Schippers, R.R., 2002b.

Sources of illustration Hitchcock, C.L., Cronquist, A. & Ownbey, M., 1959; Roe, K.E., 1971.

Authors M.L. Manoko & G.M. van der Weerden

SOLANUM ANGUIVI Lam.

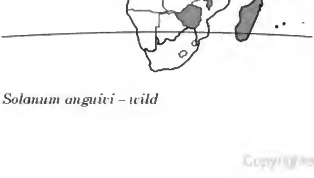
Protologue Tabl. encycl. 2: 23 (1794).
Family Solanaceae
Chromosome number $2n = 24$
Synonyms *Solanum distichum* Schumach. & Thonn. (1827), *Solanum indicum* auct. non L., *Solanum anomalum* auct. non Thonn.

Origin and geographic distribution *Solanum anguivi* is native to Africa, widely distributed on the African continent and its neighbouring islands and Arabia. It has been recorded from West Africa, as well as Central Africa, East Africa, southern Africa and Madagascar, but it probably occurs in all non-arid regions throughout tropical Africa. It grows mostly in the wild, but sometimes, e.g. in Uganda and Côte d'Ivoire, it is a semi-cultivated vegetable.

Uses The green fruits of *Solanum anguivi* are collected and consumed as a vegetable. In Ghana they are used as an appetizer. In Cameroon, the small bitter fruits are an important ingredient of a dish, called 'nkwi'. Fruits are used fresh or dried and ground as medicine against high blood pressure. In compounds the plants with their masses of red berries are appreciated for their ornamental value.

Production and international trade *Solanum anguivi* fruits are sold in local markets. As they are gathered from the wild or semi-cultivated in compounds, data on production and trade are not available.

Properties The nutritional value of *Solanum anguivi* fruits is not reported, but is probably comparable to fruits of the related *Solanum aethiopicum* L. Solamargine and two steroid alkaloid glycosides, named anguivine



Solanum anguivi – wild

and isoanguivine, have been isolated from the roots and three steroidal glycosides (anguiviosides A–C) from the fruits.

Adulterations and substitutes As medicine against high blood pressure it can be replaced by dried scarlet eggplant fruits (*Solanum aethiopicum* Shum Group).

Description Shrub up to 3 m tall with spreading branches; stem often prickly, bearing small, sessile stellate hairs with 4–8 arms. Leaves alternate, simple; stipules absent; petiole 2–6 cm long, densely stellate-hairy; blade elliptical-ovate, 10–20 cm × 5–10 cm, sinuate to distinctly lobed, with 2–4 pairs of lobes 2–3 cm long, base oblique, cuneate or occasionally truncate or subcordate, apex acute to obtuse, on both surfaces with more or less sessile stellate hairs having 6–10 more or less equal arms. Inflorescence a raceme-like cyme, extra-axillary, 5–15-flowered, occasionally flowers solitary. Flowers usually bisexual, occasionally the distal flowers with short styles and functionally male, regular, usually 5-merous; pedicel 4–15 mm long; calyx densely hairy, lobes c. 3 mm long; corolla stellate, 6–12 mm in diameter, white, occasionally with pale purple veins on the outer surface, stellate hairy outside, more or less glabrous inside; stamens alternate with corolla lobes, filaments short and thick, anthers connivent, yellow, opening by terminal pores; ovary superior, 2–6-celled, style about as long as stamens, stigma small. Fruit a subglobose berry 7–18 mm in diameter, smooth, green or white when young, red when ripe, in clusters of up to 20 fruits; stalk 8–15 mm long, usually erect, occasionally decurved. Seeds subreniform, 2–3 mm long. Seedling with epigeal germination; cotyledons thin, leafy.

Other botanical information *Solanum anguivi* is a variable species. It exhibits tremendous variation in prickliness and pubescence, and in its inflorescence. This variation is possibly partly due to domestication and selection. There has been a shift from prickly, many-flowered and small-fruited types to prickleless, few-flowered and large-fruited types. Fully wild or weedy plants can have very prickly leaves and stems; such plants are usually weeded out and are thus not encountered in gardens. *Solanum anguivi* is often found in a semi-cultivated state. It is dispersed by birds, which drop the seeds after feeding on the berries.
Several subspecies and varieties of *Solanum anguivi* have been recognized. *Solanum anguivi* is most likely the wild progenitor of the scarlet eggplant (*Solanum aethiopicum* L.), commonly cultivated in tropical Africa, possibly via the semi-domesticated *Solanum distichum* Schumach. & Thonn., which is here considered as an element of *Solanum anguivi*, and which may well be treated as a cultivar-group. *Solanum anguivi* crosses with all groups within the *Solanum aethiopicum* complex, and the whole group might be considered as a single biological species. The F_1 plants, however, are less fertile, and the morphological differences are considerable; therefore they are considered here as two separate species. Occasionally *Solanum anguivi* is confused with *Solanum torvum* Sw., which has larger clusters of fruits.

Solanum anguivi – 1, flowering and fruiting shoot; 2, flower; 3, fruit.
Redrawn and adapted by Achmad Satiri Nurhaman.

Growth and development Flowering starts 2–3 months after germination. Flowers open early in the morning when it is still dark. *Solanum anguivi* is mainly self-pollinated, but outcrossing by bees may take place. The stigma is receptive some hours before the flowers are open and remains receptive for about two days. Most plants survive for one rainy season and die in the dry season, but occasionally large plants of about two years old may be found.

Ecology *Solanum anguivi* prefers relatively

humid localities, being rare in arid ones. Usually it is found as a weed in gardens or disturbed areas. Primitive very prickly and hairy types can be found in forest habitats, ranging from primary to slightly disturbed forest.

Propagation and planting The seeds are often dispersed by birds in farmers' fields where the plants grow as a weed, but are often not removed by the farmers since the fruits are picked and eaten. Emergence of the seedling starts about a week after sowing. In gardens, plants are spaced 100–150 cm apart to allow for vigorous horizontal branching. Spacing may be wider if a few plants are left to grow in a garden among other crops.

Management Since a few plants are normally found scattered in fields of other crops, there are no special management techniques for *Solanum anguivi*. Occasionally some branches may be pruned to stop the plant from becoming too bushy. Cultivation is rarely practised, but the same cultivation techniques as for *Solanum aethiopicum* may be used.

Diseases and pests *Solanum anguivi* is susceptible to the rust *Puccinia substriata* var. *indica*, but in general it is very resilient and resistant to diseases and pests that affect many other *Solanum* species, e.g. bacterial wilt.

Harvesting The harvest of the fruits starts 2.5–3 months after plant establishment. Fruits are ready for picking 2–3 weeks after fruit set, i.e. when they have reached a reasonable size but are still immature and green. Only the quantity needed for immediate consumption is picked. The crop keeps producing for up to a year or more. When seeds are required, fruits are allowed to reach full maturity turning orange-red in colour, i.e. about 4–6 weeks after fruit set.

Yield A plant yields some handfuls of pea-sized fruits per month.

Handling after harvest Fresh fruits of *Solanum anguivi* are easily transported and can be kept in good condition for some time, especially in shade or in a cool place. Sun-drying of fruits after cooking is practised to preserve them. The dried fruits are ground into powder and added to soup when required.

Genetic resources Being mainly a weedy species and widely distributed in Africa, *Solanum anguivi* is not threatened. Farmers maintain the species by sparing the wanted types from being weeded from their fields. Over 50 samples of *Solanum anguivi* collected in the 1980s were kept at the University of Birmingham (United Kingdom), but most of the material has been taken over by the University of Nijmegen (Netherlands).

Breeding Genetic improvement of *Solanum anguivi* has not been reported. However, it has been used in the breeding of other species. In Uganda, *Solanum anguivi* was crossed with *Solanum aethiopicum* to raise F_1, F_2, BC_1 and BC_2 generations to be evaluated for 15 quantitative and qualitative traits. Highly significant levels of hybrid vigour were detected in harvest date, number of fruits per plant, fruit size and weight, and leaf index. Fleshy and strongly attached versus thin and easily removed peduncle, green versus white colour of unripe fruits, and prickly versus non-prickly condition showed monogenic inheritance.

Prospects *Solanum anguivi* is a valuable semi-domesticated indigenous vegetable in many areas, with potential to become a cultivated market vegetable. Breeding for plant habit, earliness, fruit quality and yield merits attention.
Solanum anguivi is of potential use as genitor in breeding programmes aimed at improvement of *Solanum aethiopicum* for disease resistance, e.g. to bacterial wilt (*Ralstonia solanacearum*), and to increase the number of fruits per infructescence.

Major references Bukenya Z.R., 1980; Bukenya, Z.R., 1993; Schippers, R.R., 2000; Schmelzer, G.H., 1990.

Other references Anaso, H.U., 1991; Anaso, H.U., Okerere, G.U. & Uzo, J.O., 1990; Bitter, G., 1923; Bukenya, Z.R. & Carasco, J.F., 1999; Bukenya, Z.R. & Hall, J.B., 1988; Jaeger, P.M.L., 1985; Lester, R.N. & Niakan, L., 1986; Lester, R.N., Jaeger, P.M.L., Bleijendaal-Spierings, B.H.M., Bleijendaal, H.P.O. & Holloway, H.L.O., 1990; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Ripperger, H. & Himmelreich, U., 1994; USDA, ARS & National Genetic Resources Program, 2001; Wilson, J.P, Phatak, S.C. & Lovell, G., 1996; Zhu, X.H., Ikeda, T. & Nohara, T., 2000.

Sources of illustration Nabakooza, J., 2003b.

Authors R. Bukenya-Ziraba

SOLANUM ANOMALUM Thonn. ex Schumach.

Protologue Beskr. Guin. pl.: 126 (1827).
Family Solanaceae

Origin and geographic distribution *Solanum anomalum* occurs from Sierra Leone to

southern Nigeria, Cameroon and DR Congo.

Uses The ripe red fruits of *Solanum anomalum* are collected from the wild and cooked in soups and sauces, or eaten fresh. They taste bitter and are normally only eaten fresh by older people. When dried the fruits can be stored. The leaves are not eaten. In West Africa sap from the leaves and fruits is drunk or taken by enema 1–2 times daily as a treatment for leprosy. In Nigeria the fruits are used as a laxative and digestive. They are also served ground up in soups and sauces as an appetizer for sick persons, sometimes mixed with fruits of *Parkia*. In DR Congo leaf sap is drunk against gonorrhoea and crushed fruits are applied to maturate inflammations on fingers or toes. In Ghana fruit juice was applied to sores on the ears to alleviate pain.

Botany Shrub up to 2 m tall, usually armed with prickles up to 5 mm long on stem, branches and midrib of the leaves. Leaves arranged spirally, simple; petiole 3–6 cm long; blade ovate to elliptical, 10–17 cm × 3–8 cm, base attenuate, margin sinuate, when young densely covered with sessile stellate hairs at both sides, glabrous when mature. Inflorescence an axillary fasciculate cyme, usually 15–30-flowered; peduncle c. 2 mm long. Flowers bisexual, 4–5-merous; pedicel c. 6 mm long, in fruit up to 2 cm; calyx c. 5 mm long; corolla 5–6 mm long, white, with stellate hairs on outer surface. Fruit a globose berry 5–9 mm in diameter, green when young, shiny red when mature. Seeds globose, 2–3 mm in diameter.

Solanum comprises over 1000 species. *Solanum anomalum* belongs to subgenus *Leptostemonum*, together with e.g. *Solanum anguivi* Lam. and *Solanum torvum* Sw., the fruits of which are also eaten as a vegetable. It is closely related to *Solanum anguivi* and is often confused with that species, also in the literature.

Management Reports on the susceptibility of *Solanum anomalum* to the shoot and fruit borer *Leucinodes orbonalis*, a serious pest of egg plant, are conflicting.

Ecology *Solanum anomalum* occurs wild in thickets and secondary forest in the drier parts of the forest zone.

Genetic resources and breeding *Solanum anomalum* is rather widespread and not in danger of genetic erosion. A few accessions are held in *Solanum* genebanks in the Netherlands and Germany.

Prospects *Solanum anomalum* will remain a minor fruit vegetable. Its taxonomy, nutritional composition and medicinal properties need investigation.

Major references Bukenya, Z.R. & Hall, J.B., 1988; Burkill, H.M., 2000; Schmelzer, G.H., 1990.

Other references Behera, T.K., Singh, N. & Kalda, T.S., 1999; D'Arcy, W.G., 1979; Irvine, F.R., 1961; Kumar, R. & Gupta, S.S., 2001; Whalen, M.D., 1984.

Authors P.C.M. Jansen

SOLANUM GROSSEDENTATUM A.Rich.

Protologue Tent. fl. abyss. 2 : 101 (1850).

Family Solanaceae

Synonyms *Solanum memphyticum* C.C. Gmel. var. *abyssinicum* (Dunal) Cuf. (1963).

Origin and geographic distribution *Solanum grossedentatum* is poorly known. It is thought to be native in Africa, occurring from Cameroon east to Ethiopia and Somalia, and south to South Africa.

Uses The leaves of *Solanum grossedentatum* are collected from the wild and used as a cooked vegetable. The fruits are eaten by children. In Kenya it is said to be grown together with maize, and the leaves are sold on local markets.

Properties No nutritional composition is known for *Solanum grossedentatum* leaves, but it is probably comparable to related African nightshades such as *Solanum scabrum* Mill.

Botany Erect to decumbent, annual or short-lived perennial herb up to 120 cm tall, often succulent, usually villose with red-brown glandular and shorter non-glandular hairs. Leaves arranged spirally, simple; petiole about as long as blade, winged; blade ovate-lanceolate, 3–7 cm × 2–4 cm, margin dentate to incised. Inflorescence a simple umbellate cyme, 3–4-flowered. Flowers bisexual, usually 5-merous; pedicel reflexed in fruit; calyx stellate, adherent to fruit; corolla rotate, c. 1 cm in diameter, white with greenish basal star. Fruit a globose berry 7–9 mm in diameter, black when mature.

Solanum grossedentatum belongs to the subgenus *Solanum* and section *Solanum*, together with other vegetable species such as *Solanum americanum* Mill., *Solanum scabrum* Mill. and *Solanum villosum* Mill. Research is still needed to better understand the species within section *Solanum* and their diversity. In Africa the name *Solanum nigrum* is often used for almost all species of section *Solanum* with blackish fruits. Most probably *Solanum retro-*

flexum Dunal is identical to *Solanum grossedentatum*, but more research is needed. *Solanum retroflexum* is a tetraploid ($2n = 48$), occurring throughout tropical Africa and introduced in North America and Australia. Its leaves are rarely eaten as a vegetable, but it has edible ripe fruits. Its indumentum is villose and consists of non-glandular hairs.

Ecology *Solanum grossedentatum* occurs in montane secondary scrub vegetation, often growing as a weed, at 800–3000 m altitude.

Genetic resources and breeding *Solanum grossedentatum* is widespread and not in danger of genetic erosion.

Prospects *Solanum grossedentatum* will remain a minor vegetable. A taxonomic revision of the section to which it belongs is badly needed.

Major references Bukenya, Z.R. & Carasco, J.F., 1995a; Burkill, H.M., 2000; Edmonds, J.M. & Chweya, J.A., 1997.

Other references Bukenya, Z.R., 1996; D'Arcy, W.G., 1979; van Wyk, B.E. & Gericke, N., 2000; Westphal, E., 1975.

Authors P.C.M. Jansen

SOLANUM MACROCARPON L.

Protologue Mant. pl. 2: 205 (1771).
Family Solanaceae
Chromosome number $2n = 24$, 36
Synonyms *Solanum dasyphyllum* Schumach. & Thonn. (1827).

Vernacular names Gboma, gboma eggplant, African eggplant (En). Gboma, aubergine gboma, anghive, aubergine africaine (Fr). Berinjela africana (Po). Ngogwe, nyanya, nyanya chungu (Sw).

Origin and geographic distribution The genus *Solanum* comprises over 1000 species worldwide. In Africa and adjacent islands it is represented by at least 100 indigenous species; about 20 of these are recent introductions. *Solanum macrocarpon* has an African ancestry. Spiny wild forms are found throughout the tropical non-arid parts of Africa, their fruits still being gathered occasionally as vegetable, whereas the cultivated forms, called 'gboma' in West Africa, constitute an important fruit and leaf vegetable, grown for the market and in home gardens. Local cultivars grown for the leaves are common throughout West and Central Africa, while the fruit types are mainly restricted to the humid coastal areas of West Africa. Gboma has been recorded in many West African countries and probably occurs in all coastal countries. It is also widespread in Central and East Africa. In southern Africa it has been recorded as a vegetable in Malawi, Zambia, Zimbabwe and Mozambique. Several fruit cultivars can also be found in South America (Suriname) and the Caribbean, apparently introduced from West Africa, the local name in Suriname being 'ndrowa' ('ndrowa' is the name of certain types of *Solanum aethiopicum* L. in Côte d'Ivoire). It has been reported from Thailand and Indonesia, but this is probably erroneous and concerns a different species.

Solanum macrocarpon – wild and planted

Uses The young leaves and young fruits are cooked and consumed as a vegetable. The leaves are eaten as a separate dish or in sauces together with other ingredients. The taste is more or less bitter and very much liked. The leaves can either be steamed (as practised in Uganda) or fried in oil with onions. In West Africa both leaves and fruits are eaten. A popular cultivar in Benin is a small-fruited leaf type, whereas in Côte d'Ivoire a big-fruited type grown for its fruits is popular. In Uganda it is mostly the leaves that are eaten, but the fruits are added to sauces.

The leaves, fruits and roots have a variety of medicinal uses. In Sierra Leone heated leaves are chewed to treat throat troubles; in Nigeria fruits are taken as a laxative, and to treat cardiac diseases, while flowers and fruits are chewed to clean the teeth; in Kenya the juice of boiled roots is drunk to get rid of hookworms, while crushed leaves are taken to treat stomach troubles. *Solanum macrocarpon* is occasionally grown as an ornamental.

Production and international trade Leaves

Solanum macrocarpon – 1, flowering branch; 2, fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

and fruits of gboma are common market vegetables in many African countries, but statistics on production and trade are not available. There is some export of gboma fruits from Senegal and Uganda to European markets (Paris, Brussels). In the Caribbean (Santo Domingo) and Suriname gboma fruits are produced for export to the United States and Europe (Amsterdam).

Properties The composition of gboma leaves is comparable to that of other dark green leaf vegetables, while the composition of gboma fruits is similar to that of eggplant (*Solanum melongena* L.). Gboma leaves contain per 100 g edible portion: water 85.6 g, energy 176 kJ (42 kcal), protein 4.6 g, fat 1.0 g, carbohydrate 6.4 g, fibre 1.6 g, Ca 391 mg, P 49 mg. Gboma fruits contain per edible portion of 100 g (i.e. product as purchased): water 89.0 g, energy 168 kJ (40 kcal), protein 1.4 g, fat 1.0 g, carbohydrate 8.0 g, fibre 1.5 g, Ca 13 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). All *Solanum* species contain spirosolane alkaloids, including solanine and solanidine. These are bitter tasting and potentially poisonous when consumed frequently.
The petroleum ether fraction of a *Solanum macrocarpon* fruit extract showed acaricidal activity against the tick *Rhipicephalus appendiculatus*.

Description Shrub or subshrub up to 1.5 m tall; stems terete, glabrous or with stellate hairs, not prickly or with straight, robust prickles up to 6 mm long. Leaves alternate, simple; stipules absent; petiole up to 7 cm long or leaves subsessile; blade 15–46 cm × 8–30 cm, entire or with short to large lobes up to 8 cm long, hairy on both surfaces with simple or stellate hairs, later often glabrescent, prickles present or absent on leaves, when present principally on midrib and lateral veins, straight, up to 13 mm long. Inflorescence lateral, racemose, 3–12-flowered. Flowers functionally female and larger in lower part of inflorescence, functionally male with short styles in upper part, regular, 5(–6)-merous, pedicellate; calyx campanulate, lobes pointed, hairy, glandular, sometimes prickly, often accrescent in fruit; corolla infundibuliform-rotate or campanulate, 2–3.5 cm long, pale purple or purple, rarely white, glandular hairy outside, glabrous inside; stamens alternate with corolla lobes, filaments short and thick, anthers connivent, opening by terminal pores; ovary superior, 2–5-celled, glabrous or slightly glandular hairy, style in female flowers slightly longer than stamens. Fruit a depressed globose berry 2–6 cm × 3–10 cm, green, ivory or purplish white with dark stripes when young, yellow to brownish when ripe, many-seeded, partly covered by the enlarged calyx lobes; fruit stalk erect or decurved, 1–4 cm long. Seeds compressed obovoid to reniform, 3–4.5 mm × 2–3.5 mm. Seedling with epigeal germination; cotyledons leafy, subsessile, narrowly elliptical.

Other botanical information *Solanum macrocarpon* is extremely variable. It is treated here as including *Solanum macrocarpon* L. sensu stricto and *Solanum dasyphyllum* Schumach. & Thonn. (wild ancestor of *Solanum macrocarpon*). This is done because crossability experiments involving various groups of the *Solanum macrocarpon* complex, including wild *Solanum dasyphyllum* and semiwild types and cultivars, produced fully fertile F_1 and F_2 hybrids. F_1 hybrids between the cultivars of *Solanum macrocarpon* and the wild group (*Solanum dasyphyllum*) showed normal meiosis. The domestication process of *Solanum dasyphyllum* has involved selection against hairs, prickles and deeply lobed leaves.

Landraces that were selected for their fruit often show a reduction in bitterness and an increase in fruit size. The distinction between the leaf types and fruit types is not very strict because the leaves of the fruit group may also be eaten, but these are not as soft as the leafy types. The fruit types have larger (180–500 g) and softer fruits whereas the leaf types have relatively smaller fruits (<180 g), which are often rather hard and have a cracked surface.

Several cultivars of *Solanum macrocarpon* are cultivated e.g. in Ghana, where they are mainly grown for their fruit and less so for their leaves. The names given to these cultivars are either those under which they were known by farmers or named after the village where they were found. Fruits and leaves of 'Gboma', 'Mankessim', 'Akwaseho' and 'Kade' are consumed, whereas of 'Sarpeiman' and 'Bui' only fruits are eaten.

Growth and development Gboma seeds are orthodox and if kept dry and cool will maintain a high viability for several years. However, if kept at room temperature and high air humidity, viability is lost in a few months. Germination starts about a week after sowing. Flowering starts 2–3 months after germination. Cultivars grown in savanna areas flower earlier than those in high-rainfall areas and are more tolerant to drought. The crop is mainly self-pollinated. It has low levels of outcrossing, which is mainly done by bees and other pollinating insects. Flowers open early in the morning when it is still dark. The stigma is receptive some hours before the flowers open and remains receptive for about two days. Fruits are ready for picking 3–4 weeks after fruit set. Fruits take about 10 weeks to ripen and seeds should be collected from fruits, which are physiologically ripe.

Ecology Most leafy cultivars grow in high-rainfall areas of West and Central Africa. An exception is a group of cultivars with small leaves and fruits, found in the semiarid and savanna areas of Northern Ghana, Burkina Faso and neighbouring countries. Fruit cultivars are restricted to the humid coastal areas from Côte d'Ivoire to Nigeria and also along the East African coast. Gboma requires warm conditions and is only occasionally found at high altitudes, e.g. in Cameroon. At high altitudes, plants are sturdy and their growth rate is slow.

Propagation and planting The 1000-seed weight is about 1.7 g. Seeds are sown in a nursery and are spaced at 20 cm between the rows. Presoaking of seeds in hydrogen peroxide for 24 hours generally improves germination. Seedlings of leafy cultivars are transplanted after 4–6 weeks at a spacing of 50 cm × 50 cm. The spacing for fruit cultivars is about 1 m × 1 m. Fruit cultivars require more frequent watering than the leaf cultivars as drought causes seeds to develop faster making the fruits unsuitable for consumption. When preparing beds it is recommended that NPK 15–15–15 fertilizer be added at a rate of 80–100 kg/ha.

Management Commercial growers normally practise monocropping. For subsistence cultivation, farmers grow their landraces in home gardens as a sole crop or intercropped with other food crops like maize and cassava. Gboma responds well to NPK fertilizer and animal manure. When the crop is grown for its leaves, it is trimmed when about 20 cm tall to promote the production of new shoots. Abundant fruit production also follows trimming.

Diseases and pests Gboma is rather resistant to diseases and pests compared to exotic vegetables like tomatoes. Many diseases and pests have been reported to attack the crop, but most are rarely very harmful: *Puccinia penniseti* (yellow rust), *Geotrichum candidum* (rusty brown leaf spot), *Fusarium* sp., *Rhizoctonia solani*, *Verticillium dahliae* (wilt), *Gloeosporium melongenae* (anthracnose), *Leveillula taurica* (powdery mildew), *Phomopsis vexans* (phomopsis rot), *Phytophthora parasitica* (fruit rot), *Ralstonia solanacearum* (bacterial wilt), leaf curl virus, *Empoasca flavescens* (leaf hopper), *Epilachna hirta* (leaf beetle), *Epitrix cucumeris* and *Epitrix parula* (flea beetle), *Heliothis armigera* (army worm), *Leucinodes orbonalis* (fruit borer), *Meloidogyne* species (root-knot nematodes), *Psylliodes balyi* and *Psylliodes splendida* (cut worm), *Jacobiasca lybica*, *Spodoptera littoralis* (army worm), *Prodenia litura*, and *Tetranychus truncates* (red spider mite). Gboma leaves often show a deformation and a mottled viruslike appearance, caused by mites (*Polypgagotarsonemus latus*); when the symptoms appear, the mites have already migrated to the younger leaves.

Certain cultivars are resistant to *Cercospora solani*, *Thielaviopsis basicola* (damping-off disease), *Leucinodes orbonalis*, *Trialeurodes vaporariorum* (whitefly), *Amrasca biguttula* (leaf hopper), and highly tolerant to *Tetranychus urticae* (spider mite) and *Fusarium* wilting. Cultivars having fruits with a tough calyx cover and high phenolic content are more resistant to fruit borers than those without. It was observed that gboma completely resisted shoot

infestation of *Leucinodes orbonalis*, performing better than *Solanum incanum* L., which is well known for its resistance to this pest.

Harvesting Leaf harvest starts 6–9 weeks after transplanting, usually about a week after flowers have appeared. The leaves are harvested periodically and depending on the availability of water the crop continues to produce for up to a year. The whole shoot with the terminal bud and occasionally the flowers is picked. Subsequent harvests are made every two weeks and consist of side shoots. Where fruits are eaten, they are picked when still unripe, 2–4 months after sowing. Ripe fruits are harvested one month later for seed.

Yield An average leaf yield of 2.9 kg/m^2 with a crop spacing of 50 cm × 50 cm has been recorded in Nigeria. Cultivars with early regrowth are most suitable for high yields as a leaf vegetable. Leaves can be harvested for several seasons from regrowths but a new crop gives the best yield. In Senegal the cultivar 'Newubaar' has given 1.5 kg of fruits per plant in 4 months. Regular leaf harvesting decreases the fruit yield.

Handling after harvest Fresh leaves and fruits are easily transported and can be kept in good condition for some time, especially in shady or cool places. Sprinkling with water helps to keep the leaves fresh. Gboma leaves are sometimes preserved by sun-drying, but *Aspergillus* species and other storage fungi may develop on stored leaves. The dried product is broken into small pieces or ground to powder and used in soup. Fruit cultivars with a soft skin are preferred; they are easy to cook, but they do not travel well. Cultivars with a tough skin are easily transported and can be stored up to two weeks.

Genetic resources Local landraces are presently not at great risk of genetic erosion. National research institutes in Nigeria and Ghana maintain germplasm of *Solanum macrocarpon*. Since 1980, the International Plant Genetic Resources Institute (IPGRI) has organized *Solanum* species collecting missions in West Africa (Benin, Burkina Faso, Côte d'Ivoire, Ghana and Togo) and materials have also been collected from many other African countries including Nigeria, Uganda and Zimbabwe. A collection was held at the University of Birmingham (United Kingdom). Recently this material has been transferred to the University of Nijmegen (Netherlands).

Breeding In most African countries gboma is considered to be a minor crop, except in Nigeria, and therefore research to enhance the germplasm potential is scarce. Cultivar development work started in 1998 in both Cameroon and Ghana. The tremendous variability in the species, embracing the wild ancestor *Solanum dasyphyllum*, semiwild forms and cultivars from both humid and dry areas, offers a good opportunity to the breeder to improve the crop, e.g. for disease resistance.

F_1 and F_2 hybrids between the various groups of *Solanum macrocarpon* (including wild *Solanum dasyphyllum*) show heterosis and F_2 superior hybrids have been isolated as candidates for future breeding programmes. Fertile interspecific crosses of *Solanum macrocarpon* with *Solanum aethiopicum* L. and *Solanum melongena* L. are possible. *Solanum macrocarpon* is a good genitor for inducing disease- and pest resistances in eggplant (*Solanum melongena*). In India, the resistance to fruit and shoot borer (*Leucinodes orbonalis*) is incorporated in eggplant by crossing.

Prospects Gboma with its slightly bitter taste is liked by consumers. The high nutritive value of the leaves and the high leaf and fruit yield, as well as the fairly high resistance to pests and diseases make the crop interesting for development. The leafy cultivars have potential for introduction in semiarid areas to improve the nutritional status of the population. The fruity cultivars have potential for promotion in hot humid areas. The considerable variation within the species gives it high potential for breeding for various purposes. Development of the export market will require uniform cultivars and putting in place a good system of post-harvest handling.

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SOLANUM MELONGENA L.

Protologue Sp. pl. 1: 186 (1753).

Family Solanaceae

Chromosome number $2n = 24$

Synonyms *Solanum insanum* L. (1767), *Solanum esculentum* Dunal (1813), *Solanum incanum* auct. non L.

Vernacular names Eggplant, aubergine, brinjal (En). Aubergine, bringelle, mélongène (Fr). Beringela (Po). Mbiringanya, mbilingani (Sw).

Origin and geographic distribution Wild *Solanum melongena* is found in the area of Myanmar–Yunnan where it developed from the *Solanum incanum* complex, which had previously migrated into Asia from the Middle East and East Africa. Domestication took place in the area between India, Myanmar and China, where many primitive or weedy eggplant types are still found. The first reports of the use of *Solanum melongena* as a cultivated species in Sanskrit and Chinese agro-botanical literature date back about 2000 years. Eggplant was known in Iran as early as the 6–7th century AD. Following the great Muslim expansion westwards (8–9th century AD), eggplant moved towards the Maghreb and probably further south to the oases of the Sahara and tropical Africa, as well as to southern Europe. It was described in Ethiopia in the 14th century. Nowadays eggplant is cultivated worldwide, but its two main production regions are Asia and the Mediterranean.

Solanum melongena – planted

Uses The immature fruit of eggplant is eaten when it is attractively coloured and glossy, and the seeds are still immature. When mature, the fruit flesh is fibrous and bitter, and the seeds are hard. The fruit can be eaten fresh or after rehydration of dried slices. The flesh has a fine texture and a taste close to that of mushrooms, but sometimes stronger or even quite bitter. Most often the fruits are eaten grilled, fried or steamed, or stewed with other vegetables, meat or fish, or roasted, braised in ashes and seasoned with garlic, onion, spices, sugar, oil, soybean sauce etc. The fine texture and taste go together harmoniously with various vegetables, meat, fish and spices, making it a popular vegetable in many countries. Saponins play an important role in the development of the richness of the flavour. In South-East Asia, the fruits of certain cultivars are used raw. They are also made into pickles in vinegar (Iran, Egypt) or sweet jam (Turkey, Greece), and can be preserved by air-drying, e.g. Turkish 'dolma', or by freeze-drying, canning or deep freezing.

Eggplant is also widely used for medicinal purposes. Various plant parts are used in decoction, as powder or ash for curing ailments such as diabetes, cholera, bronchitis, dysuria, dysentery, otitis, toothache, skin infections, asthenia and haemorrhoids. Eggplant is also ascribed narcotic, anti-asthmatic and anti-rheumatic properties.

Eggplant has magical uses in several countries. It is used as a symbol of protection, good health and female fertility.

Production and international trade World production of eggplant in 2001 was almost 23 million t from 1.4 million ha. Asia is the main producer, in particular China (53% of the world production), India (28%) and Turkey (4%). Africa represents less than 4% of the world production and area, well over 90% of it from northern Africa. Data on eggplant in tropical Africa are incomplete, and may include African eggplants (*Solanum aethiopicum* L. and *Solanum macrocarpon* L.). Except for the market of northern Europe that is mainly supplied by production from southern Europe, most trade in eggplant is national.

Properties Eggplant fruits contain per 100 g edible portion: water 92.9 g, energy 64 kJ (15

kcal), protein 0.9 g, fat 0.4 g, carbohydrate 2.2 g, fibre 2.3 g, Ca 10 mg, P 16 mg, Fe 0.3 mg, carotene 70 μg, thiamin 0.02 mg, riboflavin 0.01 mg, niacin 0.1 mg, folate 18 μg, ascorbic acid 4 mg (Holland, B., Unwin, I.D. & Buss, D.H., 1991).

Eggplant contains saponin steroids, in particular glycoalkaloids; the main eggplant glycoalkaloids are solasonine and solamargine. It also contains saponins without a nitrogenous nucleus, called melongosides. The bitter taste in eggplant is due to these substances and depends on their concentration: in high concentrations, far above the palatability threshold, they are toxic.

Flavonoids isolated from eggplant fruits showed potent anti-oxidant activity. They had significant hypolipidemic action in normal and cholesterol fed rats. Delphinidin showed inhibitory effect on human fibrosarcoma HT-1080 cell invasion. The anthocyanin nasunin, isolated from the fruit peel, can protect against lipid peroxidation.

Adulterations and substitutes In sauces eggplant can be replaced by garden egg (*Solanum aethiopicum*).

Description Annual herb to perennial shrub up to 150(–200) cm tall, often much-branched, with long taproot; stems and leaves with or without prickles and densely covered with stellate hairs having 8–10 arms. Leaves alternate, simple; stipules absent; petiole 6–10 cm long; blade ovate to ovate-oblong, 3–25 cm × 2–15 cm, base rounded or cordate, often unequal, apex acute or obtuse, margin sinuately lobed, densely hairy. Inflorescence a 1–5-flowered cyme (flowers often solitary). Flowers bisexual or functionally male, regular, 5–8(–10)-merous; pedicel 1–3 cm long, up to 8 cm in fruit; calyx campanulate, lobes c. 1.5 cm long, enlarging greatly and splitting in fruit; corolla campanulate with broadly triangular lobes, 3–4 cm in diameter, violet, rarely white; stamens inserted near the base of the corolla tube and alternate with corolla lobes, filaments short and thick, anthers connivent, yellow, opening by terminal pores; ovary superior, 2–many-celled, style as long as or longer than stamens, stigma green, capitate, lobed. Fruit a depressed globose to ellipsoid, ovoid, obovoid or even serpentine berry, 2–35 cm long (sometimes longer), 2–20 cm broad, smoothness and shininess variable, colour at commercial stage white, green or from pale violet-purple hues to black, sometimes netted or striped, yellow to brown when ripe, many-seeded. Seeds lenticular to reniform, flattened, 3 mm × 4 mm, pale brown. Seedling with epigeal germination; cotyledons up to 2.5 cm × 1 cm.

Solanum melongena L. – flowering and fruiting shoot.
Source: PROSEA

Other botanical information *Solanum* comprises over 1000 species and includes major food species. *Solanum melongena* belongs to subgenus *Leptostemonum* section *Melongena* to which *Solanum macrocarpon* also belongs, and which have bisexual as well as male flowers. *Solanum melongena* is partially interfertile with the African cultigens *Solanum aethiopicum* and *Solanum macrocarpon*, as well as wild species in various sections of subgenus *Leptostemonum*.

Solanum melongena cultivars are so diverse that they have been described previously as many different species, but even clear separation into cultivar-groups is impossible. In tropical Africa, 'Black Beauty' is the most popular cultivar. Some cultivars are popular in particular countries, e.g. 'Ravaya' in Ghana, or 'Florida Market' in Burkina Faso. The cultivation of F_1 hybrids is not common, except to some extent for F_1 'Kalenda', a high-yielding cultivar for hot (wet or dry) climates in West Africa, tolerant to bacterial wilt and fruit anthracnose.

Growth and development Germination takes 8–12 days at the optimum range of tem-

peratures (22–28°C). The expansion of the cotyledons takes a few days and the first true leaf appears after one week. Depending on the cultivar, the first flowers appear when the plant has developed 5–12 leaves (20–30 cm tall). Vegetative growth and flowering are then continuous: after 2 leaves have developed a new flower appears on each branch and a new shoot from the axil of the leaf just below that flower.
In temperate climates eggplant is grown as an annual, in tropical climates it is a short-lived perennial (up to 2 years in commercial fields, longer in home gardens). Plant height may exceed 2 m under tropical conditions. Eggplant is autogamous but with a fairly high rate of cross pollination. Pollination is mostly by insects (mostly bumble bees or bees such as *Exomalopsis*). Fruit sets one week after anthesis, and 3–6 weeks are needed to reach commercial ripeness, depending on climatic conditions. Fruits reach physiological maturity 6–13 weeks after flowering, also depending on the climate. Good fruit production periods alternate with periods of low production.

Ecology Eggplant develops best under conditions of high temperatures, abundant light and ample water. Below 20°C and above 40°C growth and fruit set are reduced. Growth stops when temperatures drop below 10–12°C and frost kills the plants. Eggplant is not sensitive to daylength. The adaptation of cultivars to specific environments is demonstrated when they are cultivated outside the area for which they were selected. Tropical cultivars grown in a temperate climate often display slow vegetative growth and late flowering and fruit set. Chinese and Japanese cultivars present remarkably early flowering and fruit set, but their growth potential is rapidly exhausted and therefore their vegetative development is weaker than when grown elsewhere. Also, cultivars bred in winter in greenhouses in Europe often perform poorly under open field conditions in summer.
Under poor light conditions, combined with ample supplies of water and nitrogen, eggplant is susceptible to foliar gigantism and flower drop. Foliate flowers and fasciculate stems can develop after exposure of the young plants to low temperatures. Irregular water supply during fruiting disturbs the calcium supply to the fruit and results in blossom end rot or related symptoms.

Propagation and planting Seeds should be extracted from fully ripe fruits and should be dried for 48 hours, or longer if the conditions are not optimum. During the drying process exposure to direct sun must be avoided. Seed should be stored in dry and cold conditions (e.g. with some silica gel in a sealed polyethylene bag in a refrigerator). The 1000-seed weight is about 4 g. In some cultivars, some seed dormancy may occur in the weeks or months after harvest. The easiest way to get rid of it is to keep the dried seeds in a refrigerator for a minimum of 3 weeks.
Eggplant can be grown in many ways, depending on local custom and facilities: from home garden to commercial field, as sole crop or intercropped, in the open field or in greenhouses. A common cultivation method is as follows: the seeds are sown in trays or seedbeds, and seedlings are transplanted in small pots or bags (8–10 cm diameter) 2–3 weeks later when the first leaf appears. The seedlings are kept in the nursery till they have developed 5–7 leaves and are then planted in the open or in a greenhouse at a spacing of 50 cm between plants and 1 m between rows. With proper nursery management the seed requirement is about 300 g/ha, but farmers often use more. The soil should be light and well prepared. A first watering at the base of each plant is necessary just after planting. Afterwards, the frequency of irrigation depends on the soil type, season and cultural practices.

Management Eggplant is a heavy feeder and it remains in the field for a relatively long period of time. Therefore, nutrient depletion of the soil occurs quickly and for high yields fertilizer and manure requirements are large. Fertilizing should be adapted to local soil richness, rainfall conditions, and technical skills of the growers. Requirements of N, P and K are larger than for tomato. The mineral exports per 1 t of fruit are N 7 kg, P 0.7 kg and K 6 kg. In tropical Africa, fertilizer recommendations for intensive production may include 45–50 t of farmyard manure, 50–300 kg N, 25–100 kg P and 30–200 kg K per ha. The entire amount of farmyard manure, P and K are applied before transplanting. Farmyard manure is thoroughly mixed with soil at ploughing, whereas K and P are applied in furrows before or at transplanting. The N content of the soil should not be excessive, to avoid the young eggplant developing excessive foliage to the detriment of fruit production. Therefore, N fertilizers are best applied as a top dressing in three equal doses at 6, 10 and 15 weeks after transplanting. For phytosanitary reasons planting eggplants after other Solanaceous crops (e.g. tomato, pepper,

tobacco) should be avoided.
In intensive production in greenhouses, pruning is practised in order to reduce plants to 2–5 main stems. Staking is done either vertically plant by plant, or to horizontal wires along the plant row. Staking is rarely practised in Africa, but may be necessary under windy conditions; the weak axillary buds located below the first flower should then be pruned to steady the main stem. In normal open field conditions, there is no need for staking and pruning. Weeding is necessary, in particular in the young crop. Under dry conditions irrigation should be done regularly; in a humid climate irrigation is complementary to rainfall. Eggplant responds well to drip irrigation, which decreases the weed population. A too wet soil with poor drainage increases the incidence of diseases.

Diseases and pests Over thirty pathogenic aerial fungi have been described on *Solanum melongena*, a third of them being prevalent. *Sclerotium rolfsii* (southern blight) causes progressive wilting of the foliage, chlorosis and finally necrosis. *Phytophthora parasitica* (phytophthora blight), *Rhizoctonia solani* and perithecial strains of *Fusarium solani* can invade stem bases, causing damping-off or basal stem rot, in particular in case of waterlogging, or when crop residues (especially from Solanaceous plants) are left in the field. *Phytophthora parasitica* can invade and affect the fruits too. In addition, eggplant is affected by soil-borne diseases including *Phomopsis vexans* (stem and fruit pycnidial rot), to which 'Florida Market', 'Aranguez', 'Zebrina' and 'Ceylan SM164' are resistant. Other pycnidial fungi, such as a still poorly known *Phoma* species, can induce similar but milder symptoms. Under the heavy rains of southern Côte d'Ivoire *Botryodiplodia theobromae* causes fruit rot and *Choanephora cucurbitarum* and *Pythium aphanidermatum* invade stems and branches causing wet rot. *Alternaria solani* (early blight) is a frequent pathogen of eggplant causing leaf spots. Fruit anthracnose is destructive on both sides of the Atlantic ocean; it is caused by *Colletotrichum gloeosporioides* f.sp. *melongenae* in the West Indies (where the natural reservoir is *Solanum torvum* fruits), and *Colletotrichum nigrum* and *Colletotrichum capsici* in Côte d'Ivoire. The efficiency in the West Indies of the monogenic dominant resistance to anthracnose of cultivars such as 'Aranguez' and 'Zebrina' has to be tested in Africa; that of F_1 'Kalenda' has been confirmed. Powdery mildew due to *Leveillula taurica* or *Oidium lycopersicum* is quite frequent in areas where night temperatures are cool.
The most important soilborne disease is bacterial wilt (*Ralstonia solanacearum*) causing wilting of branches, followed by wilting of the whole plant. Its incidence can be reduced by good rotations; a number of tropical accessions are tolerant or resistant, e.g. 'Ceylan SM164'. Susceptible cultivars can be grown if grafted on resistant rootstocks, e.g. those of *Solanum torvum*, *Solanum aethiopicum* Aculeatum Group or 'Ceylan'. Tomato hybrid rootstocks are less successful under tropical conditions. Verticillium wilt (*Verticillium dahliae*), widespread in temperate climates, occurs in the tropics at elevations above 1000 m. Where *Fusarium* wilt is present (*Fusarium oxysporum* f.sp. *melongenae*), grafting on *Solanum aethiopicum* Aculeatum Group is recommended. Root-knot nematodes (*Meloidogyne* spp.) can provoke severe galling on the root system as well as withering, wilting and severe growth reduction of the aerial part of the plant. Eggplant is much less susceptible to viruses than tomato and capsicums: several viruses have been isolated from eggplants, but their damage is limited. Eggplant is susceptible to phytoplasms, inducing either a sudden yellowing followed by plant death, or the 'little leaf' syndrome.
Numerous insects and mites attack eggplant under tropical conditions, only the most important ones being mentioned here. Lepidopterous flower, bud or stem borers attack eggplant in Africa (e.g. *Leucinodes orbonalis*, *Daraba laisalis*, *Scrobipalpa ergasima*). Leaves are eaten by crickets and *Epilachna* flea beetles, foliar parenchyma by *Selepa docilis* and roots by termites. Biting and sucking insects include several jassid species, and the eggplant lacebug *Corythaica cyanthicollis* (synonym: *Corythaica planaris*). The aphid *Myzus persicae* frequently attacks eggplant; its proliferation can be stimulated by excessive use of fungicides, eliminating the hyperparasite *Verticillium lecanii* (synonym: *Acrostalagmus aphidum*). This emphasizes the need for Integrated Pest Management methods. Two kinds of mites can be destructive on eggplant: *Tetranychus* spp., favoured by dry hot weather and water stress, and the broad mite (*Polyphagotarsonemus latus*), infecting flowers and inducing corky spots and streaks on fruits, rather than leaf distortion as observed in African eggplants.
Subtropical Mediterranean and American cultivars are clearly more susceptible to the com-

plete array of pests and diseases of eggplant than landraces or improved cultivars from tropical countries, in particular those from South and South-East Asia.

Harvesting Harvesting must be done regularly, twice or three times per week in order to harvest fruits at the proper commercial stage, avoid plant exhaustion and maintain good growth and production. The fruit stalks can be removed with a knife or secateurs. To obtain fruits that keep well it is best to harvest at dawn or in the early morning.

Yield The yield is very variable, depending upon climate, cultural practices, cultivar, and crop duration. Under conditions of extensive production (open field, less than optimal irrigation and fertilization) it is up to 10 t/ha, whereas under very intensive production in greenhouses (e.g. in the Netherlands) the yield can jump to 370 t/ha. In Africa average yields of 40–50 t/ha from open field production of 4–5 months are possible.

Handling after harvest Eggplant fruits are susceptible to rapid dehydration after harvest, losing their colour, brightness and smoothness. The younger and the longer the fruits, the more susceptible they are to dehydration. Therefore, aubergines must be harvested at the proper development stage, and must be transferred rapidly from the field to a cool and shaded place. They should be sold within a few days after harvest. Under controlled conditions fruits can be kept up to 10 days; the storage temperature should not drop below 15°C to avoid cold injury.

Genetic resources Eggplant genetic resources consist of three genepools. The primary genepool consists of traditional and modern cultivars of *Solanum melongena*; the diversity is important in terms of fruit size (from some tens of g to over one kg), fruit shape (from globose to snake-shaped, furrowed or smooth) and fruit colour (white, green, pink to violet or purple or even black, uniform, striped, mottled or netted). The secondary genepool is formed by some 20 related *Solanum* species that are relatively easily crossable with eggplant and give relatively fertile hybrids; *Solanum aethiopicum* belongs to this genepool, but the hybrids, though quite easily obtained, have very low fertility. The tertiary genepool consists of about 20 other *Solanum* species that are crossable with eggplant using particular procedures such as embryo rescue or colchicine treatment, and produce interspecific hybrids of low fertility; *Solanum macrocarpon* belongs to this genepool.

Eggplant has suffered genetic erosion where hybrids have replaced traditional and local cultivars. As early as the 1970s it was classified by the International Board for Plant Genetic Resources (IBPGR, later IPGRI) as one of the important vegetables for which genetic resources should be collected and conserved. In cooperation with IPGRI, India (almost 3000 accessions) and China (about 1000 accessions) have made noticeable efforts to collect and conserve their native eggplant diversity. Other significant eggplant germplasm collections in Asia are maintained by the National Institute of Agrobiological Resources, Japan and the Asian Vegetable Research and Development Center, Taiwan. In Russia, the Vavilov Institute in St Petersburg maintains more than 1000 accessions and in the United States a significant collection is kept in the Beltsville Research Station of USDA. In the European Union a network comprising seven countries is regenerating and characterizing their eggplant genetic resources (EGGNET project). Genetic resources of eggplant and related species have been largely under-utilized till now, but the development of networks which create better access to information and seeds should stimulate their use in research and breeding programmes in the near future.

Breeding Eggplant is an autogamous species, with a strong tendency to cross pollination whenever there are pollinating insects (mostly *Hymenoptera*). Therefore controlled pollination is necessary for the maintenance of pure lines. The wide genetic diversity in *Solanum melongena* germplasm (e.g. fruit traits, earliness, resistance to diseases and agro-climatic adaptation) is more widely used by breeders from tropical countries than by those from temperate countries, where the production and marketing are highly standardized.

In temperate countries the seed market has been dominated for more than 20 years by F_1 hybrids, adapted to the requirements of intensive production. For the tropical market, landraces and open-pollinated cultivars are being progressively replaced by F_1 hybrids. F_1 'Kalenda', co-developed by INRA-IRAT in 1975, was one of the first hybrids especially designed for the tropics. It was first commercialized in the French West Indies and is still grown in Africa. It combines a good yield of purple fruits (intermediate shape), with resistance to *Ralstonia solanacearum* and fruit anthracnose.

In Europe as well as in Asia, research is in progress to identify and characterize new

sources of resistance to bacterial wilt (*Ralstonia solanacearum*), Verticillium and Fusarium wilt, root-knot nematodes and various viruses within *Solanum melongena* germplasm as well as in related species. Several Asian *Solanum melongena* accessions as well as accessions of *Solanum aethiopicum* Aculeatum Group and Gilo Group display high levels of resistance to bacterial wilt. However, the efficiency of most of the resistances varies with the geographic origin of the bacteria isolates, and further research is needed to better understand these interactions. Open-pollinated eggplant cultivars of diverse fruit shapes, sizes and colours were created by INRA (French West Indies) in the 1980s, from recurrent selection programmes involving these intraspecific and interspecific sources of resistance. Testing of this material is still in progress.
Several vegetable breeding companies, in particular from Asia, commercialize cultivars of different fruit types which are adapted to the climatic and pathological conditions of the tropics (e.g. East West Seed Company from Thailand and Tropicasem from Senegal). In Tanzania the AVRDC Regional Center for Africa also created a number of improved lines of eggplant.
The creation of transgenic eggplants for resistance to insects and abiotic stress factors is actively pursued in many countries. The emergence of transgenic cultivars can be expected in a short time, though their superiority over conventionally bred cultivars remains to be demonstrated.

Prospects Eggplant has good prospects in tropical Africa. Related *Solanum* species constitute a rich potential of genetic diversity. Their characterization for tropical pests and diseases is highly desirable. The recent publication of the first eggplant molecular map, using markers already located on the tomato genome, has shown that there is a lot of synteny between eggplant and tomato. This means that a great part of the knowledge of tomato genetics could be used in eggplant breeding, and that molecular tools will probably soon be used. However, field experimentation remains the ultimate and the most discriminating breeding tool for creating good cultivars.

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Sources of illustration Sutarno, H., Danimihardja, S. & Grubben, G.J.H., 1993.

Authors M.-C. Daunay & M.L. Chadha

SOLANUM SCABRUM Mill.

Protologue Gard. dict. ed. 8: Solanum No 6 (1768).

Family Solanaceae

Chromosome number $2n = 72$

Synonyms *Solanum guineense* (L.) Mill. (1768), *Solanum nigrum* auct. non L.

Vernacular names African nightshade, black nightshade, garden huckleberry (En). Morelle de Guinée, morelle noire (Fr). Erva moura (Po). Mnavu (Sw).

Origin and geographic distribution *Solanum scabrum* occurs as a cultivated vegetable from Liberia to Ethiopia, and south to Mozambique and South Africa. It is very common in lowland as well as highland regions in West and East Africa. It is also reported from Réunion and may well occur on other Indian Ocean islands, where its status needs to be confirmed. The wide range of diversity of *Solanum scabrum* found especially in Nigeria and Cameroon suggests that its origin is likely to be in the warm humid forest belt of West and Central Africa. Outside Africa, *Solanum scabrum* can be found in Europe, Asia (India, China and the Philippines), Australia, New Zealand,

Solanum scabrum – planted

North America and the Caribbean.

Uses Leaves and fresh shoots of *Solanum scabrum* are widely used as a cooked vegetable. They are served with corn 'fufu', plantains, sweet potatoes, potatoes, yams, maize or pounded cocoyams. *Solanum scabrum* is popular in Côte d'Ivoire (known as 'fouet'), Benin ('ogomoh'), Nigeria ('ogunmo' or 'odu') and Cameroon ('osan' or 'zom'). As it has a bitter taste, some people prefer not to use salt. Contrary to what is reported in older literature, fruits of *Solanum scabrum* are not eaten in Africa. Reports on its edible fruit from South Africa probably refer to *Solanum retroflexum* Dunal, and from North America, Asia, Australia and New Zealand refer to types or cultivar-groups that do not occur in Africa. In south-western Nigeria the inflorescence with buds, flowers and small fruits is normally removed before cooking; it can be very bitter in taste but this is appreciated by elderly people who may add them to their soup. Bitterness is reduced by discarding the cooking water and replacing it with fresh water. The cooking water may be very dark, which is not appreciated. Some people add milk or salt to further reduce the bitterness.

Solanum scabrum is widely used as medicinal plant. Leaf extracts are used to treat diarrhoea in children and certain eye infections and jaundice. In East Africa the raw fruit is chewed and swallowed to treat stomach ulcers or stomach-ache. Infusions of leaves and seeds are rubbed onto the gums of children who have developed crooked teeth. In the literature many other medicinal uses for *Solanum* species with black fruits have been recorded, but it is not likely that these refer to *Solanum scabrum*. *Solanum scabrum* is used as fodder for cattle and goats. Both the leaves and fruits are a source of dyes. The anthocyanin pigments in the purple to black fruits are used as a dye or as a kind of ink.

Production and international trade *Solanum scabrum* is commonly cultivated on smallholder plots, in kitchen gardens and increasingly near the major cities for market supply. No reliable statistics on production are available. It is one of the most important leafy vegetables in West and especially Central Africa, less important in East Africa. The crop is exported from Cameroon to Nigeria and Gabon. Yaoundé retail price statistics show that *Solanum scabrum* prices are lowest from May to October and rise to a peak price towards the beginning of the rainy season in March. The price per bundle remains constant, but the quantity and quality per bundle vary considerably.

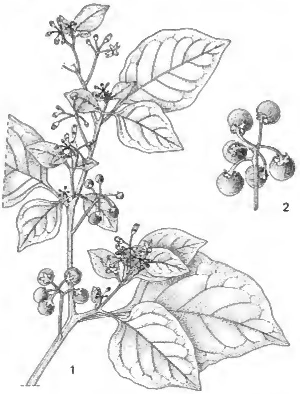
Properties The composition of 100 g edible portion of African nightshade leaves is: water 87.8 g, energy 163 kJ (39 kcal), protein 3.2 g, fat 1.0 g, carbohydrate 6.4 g, fibre 2.2 g, Ca 200 mg, P 54 mg, Fe 0.3 mg, β-carotene 3.7 mg, ascorbic acid 24 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). The dry matter content varies greatly, from 6–18 % depending on plant age, soil moisture and fertilizing. The protein is rich in methionine.

Green fruits contain comparatively high amounts of the glycoalkaloid solanine and the less poisonous solanidine. The initial effect of solanine poisoning includes diarrhoea and vomiting, and frequent consumption of this compound may lead to accumulation in the liver, causing dizziness, mental confusion and loss of speech, and it can even result in blindness. The leaves contain only low levels of these alkaloids, which are probably associated with its bitter taste. Unfortunately, heating or frying will not reduce the toxic effects of solanine and solanidine. The acceptable limit for these alkaloids is 20 mg per 100 g fresh weight of the edible portion. Most research stations in Africa have no facilities to analyse these alkaloids and are thus not able to screen accessions for this important characteristic. The degree of bitterness is easier to establish, and research is currently ongoing to determine how the glycoalkaloids relate to bitterness.

Adulterations and substitutes In dishes *Solanum scabrum* leaves can be replaced by those of other species of the section *Solanum*,

e.g. *Solanum americanum* Mill. or *Solanum villosum* Mill. with a comparable taste and bitterness, and sometimes also by *Solanum aethiopicum* L. or *Solanum macrocarpon* L. leaves.

Description Annual or short-lived perennial herb, erect and widely spreading, up to 100(–150) cm tall, unarmed; stem rounded or narrowly winged with more or less toothed wings, glabrous or sparsely pubescent, young stem more or less pubescent with short, simple hairs. Leaves arranged spirally, sometimes almost opposite, simple; stipules absent; petiole 2–10 cm long; blade rhomboid to ovate-lanceolate, up to 4.5–22 cm × 3–16 cm, cuneate at base and decurrent along the petiole, acute to acuminate at apex, sometimes obtuse, entire to sinuate or slightly toothed, glabrous or sparsely pubescent. Inflorescence an extra-axillary, umbel-like cyme, 3–10(–12)-flowered; peduncle 1–2.5 cm long, elongating up to 4 cm in fruit. Flowers bisexual, regular, 5-merous; pedicel 4–9 mm long, elongating to 12 mm in fruit, erect or nodding; calyx cup-shaped, 2–4.5 mm long, lobes triangular, becoming reflexed in fruit; corolla stellate, 7–16 mm in diameter, white or flushed purple with basal yellow-green star, lobes ovate-elliptical, 3–6 mm long; stamens inserted on corolla throat, filaments c. 1 mm long, with hairs on inner side, anthers connivent, 2–3 mm long, usually brown-yellow, opening by terminal pores; ovary superior, conical to ovoid, c. 1.5 mm long, style 3–4.5 mm long, hairy in the lower part, stigma capitate, pale green. Fruit a globose berry 10–16 mm in diameter, glossy deeply purple to purplish black at maturity, many-seeded. Seeds discoid, 2–3 mm long, creamy coloured, often tinged with purple. Seedling with epigeal germination; hypocotyl 4–5 mm long; cotyledons leafy, elliptical, 4–6 mm × 2–3 mm.



Solanum scabrum – 1, flowering and fruiting branch; 2, infructescence.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Solanum scabrum* belongs to the subgenus *Solanum* and section *Solanum*, formerly known as section *Maurella*, or section or subsection *Morella*. Currently about 30 species are included in this section of which 10–12 are known to occur in Africa. Research is still needed to better understand the species within section *Solanum* and their diversity. In Africa the name *Solanum nigrum* is often used for almost all species of section *Solanum* with blackish fruits, including *Solanum scabrum*. This confusion is probably aggravated by the use of vernacular names whereby one name can apply to several species, or several names to the same species. *Solanum scabrum* is often confused with *Solanum americanum*, but more slender stems, narrower leaves and smaller flowers and fruits distinguish the latter.

Growth and development Seed germination can be problematic because of low vigour caused by improper seed extraction and therefore inadequate removal of sugars and germination inhibitors present in the fruit. Other causes of problematic germination are that seeds are not dried and stored properly, or that the seed is dormant. The seeds can remain viable for several years when kept dry and cool. After seed emergence, growth is fast. The first flowers appear 8–11 weeks after sowing.

Flowering occurs earlier when the seeds are sown directly than when seedlings are transplanted. The plant continues to produce new flowers for several months. The flowers are mainly self-pollinated. *Solanum scabrum* has low levels of out-crossing, which is mainly done by honeybees, bumble bees and black syrphid flies.

Ecology The optimum temperature for seed germination is 15–30°C and for growth it is 20–30°C. *Solanum scabrum* grows from sea-level to well over 2000 m but does not tolerate night

frost. The rainfall during the growing season should be at least 500 mm; it grows well under conditions with much higher rainfall but then becomes susceptible to leaf diseases. It prefers fertile soils, with high nitrogen content and rich in organic matter. Sandy loams to friable clay soils with a pH of 6.0–6.5 are suitable. The plants tolerate some shade, but grow better when exposed to full sun as long as they have adequate access to water.

Propagation and planting Propagation of *Solanum scabrum* is by seed and, less commonly, by cuttings. Most farmers produce their own seed and some buy their seed or seedlings from specialized producers. For a subsistence crop seeds are sown directly at the beginning of the rainy season. There are about 1000 seeds per g. A few (3–10) seeds are used per hole when sown among other crops in an intercropping system. The strongest plants are kept and the others removed as the first harvest or for transplanting. Direct sowing during the wet season results in taller plants and, when there is adequate room, in more and larger leaves and branches and higher dry matter content than with transplanting.

Sowing in nurseries and transplanting is normally practised when the crop is cultivated commercially. The seed can be mixed with ash, sand, soil, or dry poultry manure before broadcasting to spread the fine seeds evenly. The nursery requires manure for a good emergence of seedlings. Seeds are sown in lines 10–20 cm apart or seeds are broadcast. The soil of the nursery bed should be loosened to facilitate rooting. After sowing, the beds should be covered with a thin layer of soil, which also helps to prevent ants from carrying off the seeds. Sometimes the weed vegetation in the field is burnt to provide a layer of ash that is rich in nutrients, especially potash, and also to kill soil-borne pathogens and weeds. Transplanting takes place 4–6 weeks later, depending on prevailing temperatures, when the seedlings are at least 6–8 cm tall and have 5–6 true leaves, but are not more than 15 cm tall to avoid weak and thin plants. The seedlings are selected for their strength and freedom from diseases and planted late in the afternoon or early in the morning. Adequate water is needed just before and immediately after transplanting since roots are sensitive to drought.

When propagation by cuttings is practised, cuttings of 20–30 cm long are taken from the main stem and are trimmed before they are inserted into the soil. The spacing is 40 cm × 40 cm or even 40 cm × 60 cm, considering that plants may reach 1 m in height (if not trimmed). The advantage of this propagation method is that the first harvest can start early (3–4 weeks after planting). However, the total yield is lower than from transplanted seedlings or from plants sown directly.

Usually farmers use sole cropping. The spacing may differ, depending on cultivar and season. It is usually wider during the rainy season, when ventilation is required to reduce the incidence of diseases. Spacing is normally between 15–25 cm × 15–40 cm. A wider spacing is used when the crop is to be kept for a long period, encouraging stronger branches and an extended harvest period for which additional fertilizing is needed. Branching is stronger at a wider spacing, making up for the lower number of plants. Close planting is mainly used when the growing season is expected to be short or with once-over harvesting.

Management Daily irrigation is necessary for the first week after transplanting, especially during the dry season. The irrigation frequency can later be reduced to two or three times per week, depending on temperatures, cloud cover or possible rains. Watering can be carried out through the paths between raised beds or by using a hose or a watering can. Overhead irrigation is less appropriate because of the potential spread of foliar diseases. Weeding is needed during the early stages of development. Nightshades require large amounts of nitrogen and other nutrients. Consequently, they do well in soils that are rich in organic matter, and also grow well on land covered with ash from recently burnt vegetation. Farmers use NPK 20–10–10, urea or ammonium sulphate when there is no poultry or farmyard manure available. Poultry manure is recommended at a rate of 15 t/ha alone or in combination with 400 kg/ha NPK 10–10–20. Side dressing is practised after every second harvest. However, high nitrogen levels reduce the dry matter content of the plants and make the crop more vulnerable to diseases unless the balance with potassium is correct. They also increase the level of unwanted nitrates in the leaves.

Diseases and pests Many pests and pathogens of tomato also occur in *Solanum scabrum*. A major disease of African nightshades grown in the wet season of tropical highlands is late blight, caused by *Phytophthora infestans*. Yield losses of up to 100% have been reported for susceptible cultivars in the nursery and up to

45% in the field. Control is possible with three-weekly sprays of metalaxyl + mancozeb (Ridomil MZ, 2.5 kg/ha). Some *Solanum scabrum* cultivars in Cameroon are resistant to late blight. Another important disease is early blight (*Alternaria solani*), which occurs more in lowland regions. Other diseases include greyish-green leaf mould (*Cladosporium oxysporum*), eye spot (*Cercospora nigrescens*), powdery mildew (*Leveillula taurica*), bacterial wilt (*Ralstonia solanacearum*) and root-knot nematodes (*Meloidogyne* spp.). Bacterial wilt has been recorded in Kenya and Tanzania. Prominent viral diseases are yellow-vein virus (observed in Cameroon and Nigeria), probably transmitted by whitefly (*Bemisia tabaci*), and leaf curl and leaf mosaic viruses.
Common insect pests are black ants, elephant grasshopper (*Zonocerus variegatus*) and beetles (*Lagria* spp., *Podagrica* spp. and *Epilachna hirta*). Insect pests that are occasionally encountered include *Cletus* and *Bathycoela* species (*Heteroptera*) and larvae of an unidentified lepidopterous species. Black aphids (*Aphis fabae*) cause leaf curl. A traditional cure for pests is wood ash spread onto the leaves. Insect problems can generally be controlled with deltamethrin sprays. Some consumers in Cameroon regard insect damage on leaves as proof that insecticides have not been applied.

Harvesting It takes about 4–5 weeks from transplanting to the first harvest for *Solanum scabrum*, when stems are cut down to about 15 cm from the ground, allowing new side shoots to develop. The length of harvested shoot varies from 15–50 cm, depending on the cultivar. Further harvests take place at 7–14 day intervals, on average 3–5 times/plant if there is no additional manure or fertilizer, but large-scale commercial farmers will harvest up to 10 times.

Yield Optimum yields are obtained during the third or fourth harvest, which is about two months after planting. Yields of 7–27 t/ha are reported per harvest. Yields decline significantly after the sixth harvest unless adequate fertilizer is applied. Cumulative yields may reach 40 t/ha.

Handling after harvest The produce is tied in bundles and sent to the market, where traders will split those bundles into smaller retail units. It is important to place the bundles in an upright position, especially when the time between harvesting and the final sale is more than six hours. If long stems are laid down horizontally, their heads are likely to turn upwards, making them less attractive. Traders at the market sprinkle some water on the leaves to keep them fresh. Harvested plants with their roots still attached need to be cleaned thoroughly. When they are placed in a bucket with water, they will remain fresh for a much longer time than the shoots alone.

Genetic resources At present all African nightshades are grown from local cultivars, and there is no danger of genetic erosion. Besides, *Solanum scabrum* occurs in many different countries. The largest germplasm collection is maintained at the University of Dschang, Cameroon. Another substantial collection is maintained at the Botanical Garden of Nijmegen University (Netherlands), and a small collection of local cultivars is maintained at NIHORT, Ibadan, Nigeria.

Breeding *Solanum scabrum* and other African nightshades are predominantly self-pollinating, although there are differences among species. In breeding, the absence of a self-incompatibility system is useful in stabilizing any crossings made, whereby the new population will be sufficiently uniform after only 2–3 generations. Cultivars can thus be created within a short period. Seed crops should be planted in blocks and not in lines; the outer rows should be discarded and fruits only collected from the inside of the block because pollinating insects may cause some cross-fertilization. For a seed crop the planting distance should be 50–100 cm × 50–100 cm, depending on the cultivar. Interspecific crosses of *Solanum scabrum* with *Solanum macrocarpon* or *Solanum aethiopicum* produced mature fruits but no viable seed.

Prospects It is worth promoting *Solanum scabrum* as it is an excellent leaf vegetable and a major source of income for many vegetable farmers and traders in urban and rural areas. Selection and breeding of improved cultivars with high growth vigour, strong resistance to pests and diseases and good consumer quality should be enhanced.

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Sources of illustration Stevels, J.M.C., 1990.

Authors D.A. Fontem & R.R. Schippers

SOLANUM SCHUMANNIANUM Dammer

Protologue Engl., Pflanzenw. Ost-Afrikas C: 352 (1895).

Family Solanaceae

Origin and geographic distribution *Solanum schumannianum* is only known from mountainous areas in Kenya and Tanzania.

Uses Young and mature fruits of *Solanum schumannianum* are eaten cooked as a vegetable, mixed with other vegetables such as peas, beans or amaranth to improve their flavour. They are also eaten raw. Fruits are offered for sale on local markets in Tanzania, and dried and pounded fruits are stored as powder. Juice of a mixture of pounded fruits, onion and lemon is used as a substitute for vinegar. A decoction of pounded fruits is used as a remedy for constipation and intestinal worms. *Solanum schumannianum* is also used for fodder and for hedge and boundary planting.

Botany Erect perennial herb or shrub up to 3.5 m tall; stem and branches densely covered with soft, purple bristles up to 8 mm long. Leaves arranged spirally, simple; petiole c. 3 cm long, bristly; blade elliptical, 6–25 cm × 2–8 cm, base cuneate, apex acuminate, margin entire, glabrous when mature. Inflorescence an apparently terminal, many-flowered corymbose cyme; peduncle up to 10 cm long, sometimes mealy hairy. Flowers bisexual, 5-merous, pendent; calyx cup-shaped; corolla rotate, c. 12 mm in diameter, with reflexed lobes, white, cream or mauve, turning brown before falling. Fruit a globose berry 6–8 mm in diameter, in dense bunches, shiny green, turning yellow and finally dark red at maturity.

Solanum schumannianum belongs to subgenus *Leptostemonum*, together with e.g. *Solanum anguivi* Lam., *Solanum anomalum* Thonn. and *Solanum torvum* Sw., the fruits of which are also eaten as vegetable.

Ecology *Solanum schumannianum* occurs in dense, evergreen and wet montane forest, in open glades and around water holes in forest areas, in moist forest remnants, in disturbed forest edges and is locally common in dry montane forest, at 1300–2700 m altitude.

Management *Solanum schumannianum* is usually collected from the wild in the rainy season. Sometimes it is also cultivated near houses.

Genetic resources and breeding *Solanum schumannianum* has a limited distribution, although it is locally common. Germplasm collection is recommended.

Prospects *Solanum schumannianum* will remain a minor fruit vegetable of local importance only in Kenya and Tanzania.

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Authors P.C.M. Jansen

SOLANUM TARDEREMOTUM Bitter

Protologue Feddes Repert. 10: 547 (1912).

Family Solanaceae

Chromosome number $2n = 48$

Synonyms *Solanum eldoretianum* auct., *Solanum eldoretii* auct., *Solanum nigrum* auct. non L.

Vernacular names Black nightshade, African nightshade, Eldorets nightshade (En). Morelle noire (Fr). Erva moura (Po). Mnavu (Sw).

Origin and geographic distribution *Solanum tarderemotum* is indigenous in Central and East Africa and is found in DR Congo, Rwanda, Burundi, Ethiopia, Kenya, Uganda and Tanzania. As a cultivated vegetable it is only known from a limited area in highland regions in Western and Central Province, Rift Valley and the south-western highlands in Kenya, and in northern Tanzania bordering these regions. Its occurrence was recently confirmed in the Mt Meru area of Tanzania, and plant populations found in south-western Tanzania may also belong to this species. The purple-fruited types found in the wild possibly represent the ancestor of the cultivated plants, which often have larger green fruits.

Uses Leaves and young tender shoots of *Solanum tarderemotum* are cooked and used as spinach or fried directly without boiling, mainly as accompaniment to the local staple food. Fruits are removed and milk is usually added to the cooked leaves and left overnight to reduce bitterness. The leaves may be mixed

Solanum tarderemotum – wild and planted

with other leafy vegetables (e.g. amaranth) to enhance their palatability. The purple-fruited types are usually more bitter than green-fruited ones. Children often eat ripe fruits of the green-fruited types raw.
Infusions of leaves, roots and young fruits are used medicinally to treat duodenal ulcers, stomach upsets, boils, swollen glands and teething problems. Cooked *Solanum tarderemotum* is recommended for malaria patients. The plants are used as fodder when there is no market for the fresh produce.

Production and international trade *Solanum tarderemotum* used to be mainly grown in kitchen gardens in mixed stands together with other vegetables. It is also picked from the wild. Of late there is an increasing demand for this crop that has led to its current commercial production. In local markets people rarely distinguish this species from other leafy *Solanum* species, that are all called 'mnavu'. There is a lack of reliable data on production and prices, but *Solanum tarderemotum* has probably overtaken *Solanum villosum* Mill. as the most popular leafy *Solanum* vegetable in Kenya. Occasional cross-border trade occurs between Kenya and Tanzania. The price at local markets is lowest during the rainy season in April and highest in the warm and dry period before the rains start.

Properties The composition of *Solanum tarderemotum* leaves is comparable to other dark green leafy vegetables.

Adulterations and substitutes In dishes *Solanum tarderemotum* can be replaced by other species of the section *Solanum*, e.g. *Solanum americanum* Mill., *Solanum scabrum* Mill. or *Solanum villosum* Mill.

Description Annual or short-lived perennial herb up to 150 cm tall, usually widely spreading with erect or prostrate branches, unarmed; stem narrowly winged with finely toothed wings, glabrous or sparsely pubescent, green to greenish purple with purplish nodes. Leaves arranged spirally, sometimes almost opposite, simple; stipules absent; petiole c. 2 cm long, winged; blade ovate to lanceolate, up to 10(–18) cm × 6(–7) cm, cuneate at base and decurrent along the petiole, acute to acuminate at apex, entire to undulate, sparsely pubescent, pale to medium green. Inflorescence an extra-axillary, simple, raceme-like cyme, 7–12-flowered; peduncle c. 2 cm long. Flowers bisexual, regular, 5-merous; pedicel 3–8 mm long, elongating up to 10 mm in fruit; calyx cup-shaped, c. 3 mm in diameter, up to 6 mm in fruit, with lanceolate to ovate or broadly triangular lobes reflexed or adherent in fruit; corolla stellate, 6–11 mm in diameter, white to pale purple, with yellow basal star, lobes 3–6 mm × 1–2 mm; stamens inserted on corolla throat, filaments 0.5–1 mm long, with hairs on inner side, anthers connivent, 1.5–2 mm long, yellow, opening by terminal pores; ovary superior, style 2–3 mm long, hairy in the lower part, stigma capitate. Fruit a globose berry 4–6 mm in diameter, pale green to purplish at maturity, dull, many-seeded. Seeds lens-shaped, c. 1.5 mm long. Seedling with epigeal germination.

Other botanical information *Solanum tarderemotum* belongs to the subgenus *Solanum* and section *Solanum*, formerly known as section *Maurella*, or section or subsection *Morella*. Currently about 30 species are included in this section of which 10–12 are known to occur in Africa. Research is still needed to better understand the species within section *Solanum* and their diversity. *Solanum tarderemotum* is close to *Solanum florulentum* Bitter, but this species has a forked, many-flowered inflorescence. Cultivated plants of both species have been called *Solanum eldoretianum* or *Solanum eldoretii* in the literature, but these names have not been published validly. However, the section *Solanum* contains a number of species that are highly diverse and the same could well apply to this species. This could be so especially if it has been cultivated over a long period of time, and this appears to be the case in contrast to *Solanum villosum*, which has probably been brought under cultivation more recently. *Solanum scabrum* is a similarly diverse species, which must have

been cultivated over a long period.

Growth and development Normally, seed germination takes place in 5–7 days. Initial seedling growth is rapid. Flowering starts when plants are about 6 weeks old, but harvesting of leaves can continue thereafter. When after several months the crop comes to its end, the farmers collect the fruits that have dropped on the ground for extraction of seeds for the next season.

Ecology *Solanum tarderemotum* occurs in a wide range of habitats from sea-level up to 3000 m altitude. It appears to tolerate drier conditions than the related *Solanum villosum* and *Solanum scabrum*. It grows best in soils high in N and P, with a high organic matter content. It is reported to grow wild in disturbed areas or as a weed on agricultural land, probably often as escapes from cultivation.

Propagation and planting Most farmers produce their own seeds rather than buying those from the market. Seed germination is sometimes problematic because of low vigour caused by improper seed extraction and therefore inadequate removal of sugars and germination inhibitors present in the fruit. Other reasons for problematic germination are that seeds are not dried and stored properly, or that the seed is dormant. The seeds can remain viable for several years when kept dry and cool. It is common practice to sow seeds in a nursery and transplant the seedlings when they are 10–15 cm tall and have at least 5 true leaves. Many growers mix the tiny seeds with fine soil, ash or dried manure before sowing. Nursery beds are mulched and irrigated daily. Well-fermented farmyard manure is incorporated into the plant beds whenever available because this gives better results than fertilizers only. Most farmers plant randomly with a spacing between plants of 15–20 cm. Other farmers may plant in lines with a spacing of 10–12 cm in the line and 30–45 cm between lines. The spacing is usually wider during the rainy season than during the dry season.

Management Plots are kept free of weeds by hoeing, but this becomes unnecessary after closing of the canopy. Farmers in western Kenya often use foliar sprays with macro and micro plant nutrients. When these are not available, top dressing with a nitrogen fertilizer is given after every harvest. These regular fertilizer applications allow the farmer to lengthen the harvest period considerably. Irrigation is needed during the dry season and this is often the limiting factor for production. A crop rotation with e.g. maize or amaranth is recommended to control nematodes.

Diseases and pests *Solanum tarderemotum* seems to be more susceptible to diseases than *Solanum scabrum* and *Solanum villosum*. Bacterial wilt (*Ralstonia solanacearum*) and the fungus *Cladosporium oxysporum* are the main diseases, but several other fungal diseases can also be noticed such as late blight (*Phytophthora infestans*), which may become problematic when farmers continue planting this crop closely during the rainy season. Some farmers use a fungicide, e.g. Ridomil-copper mixture, for control. The main pests are black aphids (*Aphis fabae*), flea beetles (*Epilachna hirta*), cutworms and nematodes. Aphids, flea beetles and cutworms are sometimes controlled by chemical spraying.

Harvesting Young shoots of 10–15 cm in length are picked starting 3–4 weeks after transplanting or 5–6 weeks after sowing. The preferred harvest method is ratoon cropping where the apical shoot is picked at the first harvest, allowing side shoots to grow. Subsequent harvests are at intervals of 1–2 weeks for the following 8–12 weeks. The harvest period for a rainy season crop without additional fertilizing is 4–6 weeks, but a well-managed crop may be harvested for up to 4 months. Regular harvesting of young shoots causes a prolonged vegetative period, whereas undisturbed plants may flower 8 weeks after seedling emergence.

Yield The average size of a plot is about 1000 m^2, where the first harvest will be about 7 sacks of 90 kg, the equivalent of 6 t/ha. The second harvest may yield 11 t/ha, the third 14 t/ha or more. Harvesting at intervals of about 2 weeks can go on for 3 months or even longer as long as there is proper pest and disease control, and regular fertilizing and irrigation. Farmers may thus get up to 80 t/ha, but those who do not provide these inputs can expect an average cumulative leaf yield per season of 12–20 t/ha.

Handling after harvest Harvested *Solanum tarderemotum* shoots are highly perishable and need to be sold as soon as possible before they wither. The best harvest time is either late in the afternoon for marketing the following day, or early in the morning on the day the produce is to be sold. Shoots may be dipped in water to keep them fresh, but more often they are wrapped in polythene sheets or banana leaves as small bundles to keep them fresh for some time.

Genetic resources In Kenya germplasm of

Solanum tarderemotum is kept at Maseno University. Other collections held at the National Seedbank and the University of Nairobi are not well labelled and represent the 4–5 species of nightshades with edible leaves that are known from Kenya. A few accessions are also maintained at the Botanical and Experimental Garden of Nijmegen University, Netherlands. The largest depository of germplasm is with the communities that utilize *Solanum tarderemotum* as a vegetable. There is a need for further collection, study and documentation concerning the ethnobotanic, agronomic and ecological aspects of this species and to carry out more surveys to gain a more complete picture of its distribution throughout East Africa.

Breeding The characteristics to be selected and bred for should specifically include disease tolerance and improved storability of the product. Currently, no known attempts to select and breed *Solanum tarderemotum* are being made.

Prospects With the recently witnessed increase in the popularity of indigenous vegetables in East Africa and the fact that it is already popular among some communities, *Solanum tarderemotum* has good prospects of becoming an economically important leafy vegetable for medium-elevation and highland regions. Biosystematic studies of *Solanum tarderemotum* and related species of the so-called *Solanum nigrum* complex are needed to understand the connections between wild and cultivated plants and to establish a clear and sound system of taxonomic nomenclature.

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Authors G.N. Mwai & R.R. Schippers

SOLANUM TORVUM Sw.

Protologue Prodr.: 47 (1788).
Family Solanaceae
Chromosome number $2n = 24, 48$

Vernacular names Pea eggplant, cherry eggplant, devil's fig, plate brush, Turkey berry (En). Mélongène-diable, bellangère bâtarde, aubergine pois (Fr).

Solanum torvum – wild and planted

Origin and geographic distribution *Solanum torvum* originates from Central and South America, where it is found from Mexico to Brazil and Peru, and is widespread in the Caribbean. It is now a pantropical weed. In West and Central Africa it is locally a kitchen garden crop, and it probably occurs in other regions of Africa as well. It is cultivated as a small-scale vegetable in southern and eastern Asia, and is especially popular in Thailand.

Uses The bitter fruits are appreciated especially by elderly people and are used in soups and sauces or are chopped together with eggplant fruits or tomatoes. *Solanum torvum* is also used in traditional medicine. When used wisely, its fruit and leaves can be used to control a range of microbial activities. The glycoalkaloid solasodine that is found in its leaves and fruits is used in India in the manufacture of steroidal sex hormones for oral contraceptives. The antimicrobial properties of the leaves have been known for some time in Central America and India, and also in Gabon people apply the leaves to cuts and wounds. In Sierra Leone, the fruit in decoction is given to children as a cough medicine, whereas in Senegal the plant is taken to treat sore throat and stomachache. In India leaves are dried and ground to powder, which is used as medicine for diabetic patients. In Côte d'Ivoire the plant is known to cause instant insanity when eaten raw and it has been used as poison for people. On soils infested with *Meloidogyne* nematodes and bacterial wilt, *Solanum torvum* is occasionally used as a rootstock for eggplant and to a lesser extent for tomato. For the latter, *Solanum aethiopicum* cv. 'Iizuka' gives better

results.

Production and international trade *Solanum torvum* is becoming more popular in West Africa as a vegetable, especially in Ghana, and collected from the wild or from home gardens, both for direct consumption and for sale at local markets. No statistical data are available.

Properties Per 100 g edible portion, young fruits contain: water 85.4 g, energy 197 kJ (47 kcal), protein 2.4 g, fat 0.4 g, carbohydrate 10.7 g, fibre 6.1 g, Ca 104 mg, P 70 mg, Fe 4.6 mg, β-carotene 390 μg, thiamin 0.12 mg, riboflavin 0.09 mg, niacin 2.6 mg, ascorbic acid 4 mg (Leung, W.-T.W., Butrum, R.R. & Chang, F.H., 1972). The leaves and fruits contain about 0.84% solasodine. In tests in India, dried fruits fried in oil and fed to mice caused hepatic tumours in 30% of the animals.

In tests in Nigeria, a methanolic extract of *Solanum torvum* fruits showed a wide spectrum of antimicrobial activities. The isoflavonoid torvanol A and the steroidal glycoside torvoside H isolated from the fruits showed antiviral activity against herpes simplex virus type 1. Studies on the effect of dried leaf powder in India showed no significant changes with respect to glucose, lipid profile, glycated proteins, total amino acids and uronic acid levels in non-insulin dependent diabetes mellitus patients. *Solanum torvum* is suspected of poisoning livestock.

Description Spreading or scrambling slender shrub, up to 3(–4) m tall, pubescent with stellate hairs; stem and branches usually with scattered prickles 3–7 mm long, slightly hooked. Leaves alternate, solitary or in pairs, simple; stipules absent; petiole 1.5–5 cm long; blade ovate, 7–20 cm × 4–18 cm, usually coarsely and sinuously 7-lobed with triangular, acute to obtuse lobes, somewhat sagittate to auriculate at base. Inflorescence a compact, branched, up to 100-flowered corymb, at first terminal, later becoming lateral; peduncle 1–2 cm long. Flowers bisexual, regular, 5-merous; pedicel 5–10 mm long; calyx with lobes 3–4 mm long, persistent; corolla stellate, c. 2.5 cm in diameter, white, lobes lanceolate, c. 1 cm long; stamens inserted on corolla throat, filaments very short, anthers connivent, 6–7 mm long, opening by terminal pores; ovary superior, globose, pubescent, style 8–10 mm long, stigma capitate. Fruit a globose berry 1–1.5 cm in diameter, yellowish, many-seeded. Seeds discoid, 1.5–2 mm long, brownish. Seedling with epigeal germination.

Other botanical information *Solanum torvum* is classified in section *Torvum* of subgenus *Leptostemonum*. This section comprises about 40 species, all of Central and South American origin. In South-East Asia cultivated types of *Solanum torvum* exist which are thornless.

Solanum torvum – flowering and fruiting branch.
Source: PROSEA

Growth and development Seeds require sunlight for germination, and shading may thus control the spread of *Solanum torvum* as a weed. The plant starts flowering after 3–4 months and continues flowering during its lifetime of up to 5 years. Birds and fruit bats eat the brownish yellow fruits and disperse the seeds through their droppings.

Ecology *Solanum torvum* establishes itself on open land in disturbed soil, along roads and on waste places, where it often turns into a weed that becomes hard to control. In Cameroon it is a characteristic pioneer species on fallow land. It is listed as a noxious weed in the south-eastern United States. It is normally found either near wetlands or in high rainfall areas, mainly in lowland regions; yet it is tolerant of dry periods.

Propagation and planting *Solanum torvum* is normally propagated by seed. The 1000-seed weight is about 3.3 g. The fresh seed shows strong dormancy. Seed is sown in a nursery and seedlings are transplanted after 5–6 weeks at a spacing of 1 m. Branch cuttings taken from high-yielding shrubs are also used

for propagation. Semi-hardwood cuttings 12–15 cm long, collected from fresh shoots and with their leaves removed, will produce roots and new shoots in 3–4 weeks.

Management Fruits of pea eggplant are mostly collected from the wild. In cultivation some care is required, including fertilizing and weeding when plants are young and irrigation, but pea eggplant is a very sturdy crop that grows without much care.

Diseases and pests Pea eggplant may suffer from some of the diseases that are found on other solanaceous crops, e.g. from *Alternaria solani* and eggplant anthracnose *Colletotrichum gloeosporioides* f. *melongenae*. The rust *Aecidium habunguense* causes orange pustules. *Solanum torvum* is sometimes damaged by aphids, *Leucinodes* fruit and shoot borers, leaf hoppers and *Spodoptera* caterpillars. It is a natural reservoir for the hemipterous eggplant lace bug *Corythaica cyanthicollis* (synonym *Corythaica planaris*) which attacks eggplant. A mosaic virus is transmitted by the aphids *Aphis craccivora* and *Aphis gossypii*. However, *Solanum torvum* is known for its resistance against soilborne pests and diseases, including *Ralstonia solanacearum* (the resistance, however, may break down at high temperatures), *Verticillium dahliae*, *Thielaviopsis basicola*, *Phytophthora parasitica* and *Fusarium solani*. It also appears to be resistant to flea beetles and *Meloidogyne incognita*. Unfortunately, crosses with the more important crops *Solanum melongena* L. and *Solanum aethiopicum* L. are not successful, but somatic hybridization with *Solanum melongena* has shown promise.

Harvesting Clusters of immature green fruits are picked by the time that these have reached the size of a pea or cherry, depending on the cultivar. They can be picked for consumption in many successive rounds, starting 2 weeks after first flowering.

Handling after harvest Pea eggplant is marketed in clusters of green, immature fruits rather than as individual fruit. The fruits can be kept for several days.

Genetic resources *Solanum torvum* is an extremely widely distributed species with weedy characteristics, and thus not threatened by genetic erosion. Accessions of it are included in several germplasm collections of *Solanum*.

Breeding In cultivation, African farmers use their own selected types. In Thailand seed of improved local cultivars is commercially available, e.g. at East West Seed Company. One cultivar is lacking prickles and another has a compact growth habit, both having big, less bitter fruits. Some Western seed catalogues offer seed for rootstock production.

Prospects Pea eggplant is locally a popular traditional vegetable. Selection of improved cultivars might enhance interest for commercial production. However, attention should be paid to the possible adverse effects of fruit consumption.

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Authors R.R. Schippers

SOLANUM VILLOSUM Mill.

Protologue Gard. dict. ed. 8: Solanum No 2 (1768).

Family Solanaceae

Chromosome number $2n = 48$

Synonyms *Solanum luteum* Mill. (1768), *Solanum nigrum* auct. non L.

Vernacular names Red-fruited nightshade, hairy nightshade (En). Morelle jaune (Fr). Mnavu (Sw).

Origin and geographic distribution *Solanum villosum* is believed to have originated in Eurasia, and is sometimes considered to have a southern European origin. It is widespread, but absent in Central and South America, and New Guinea. It has been introduced in North America and Australia. In Africa it is recorded from Tunisia, Algeria and South Africa, and from many countries of tropical Africa, e.g. in Central Africa from Burundi, in East Africa from Sudan, Ethiopia, Somalia, Kenya, Uganda and Tanzania, and in southern Africa from Zambia and Angola. In West Africa *Solanum villosum*

Solanum villosum – wild

has been recorded only from Nigeria. However, its distribution is incompletely known, and it may occur in many other countries. Its use as vegetable is most popular in East Africa.

Uses Leaves and young shoots of sparsely hairy types of *Solanum villosum* are used as a leafy vegetable. The young leaves are boiled with water and are sometimes fried. In Tanzania young shoots and leaves are picked, chopped and then boiled or, especially in urban areas, fried with onions and tomatoes and sometimes mixed with meat or fish. In the Mara region in Tanzania whole young plants are used as a vegetable. In Kenya the Luo and Pokot people prepare this vegetable together with less bitter vegetables such as amaranths, whereas other cultural groups mix it with meat, spider plant (*Cleome gynandra* L.), bitter leaf (*Vernonia* spp.) or cowpea leaves. Nandi women in Eldoret, Kenya use milk to boil the vegetable. In Uganda the young shoots and leaves are mixed with groundnut paste, wrapped in banana leaves and steamed. Other people prefer to boil the vegetable, drain off the remaining water and add sesame (*Sesamum indicum* L.) to make it a thick and more tasty sauce. In some instances, it is chopped, washed and fried either directly or after boiling it in sour milk. Groundnuts or sesame paste can be added to this preparation.

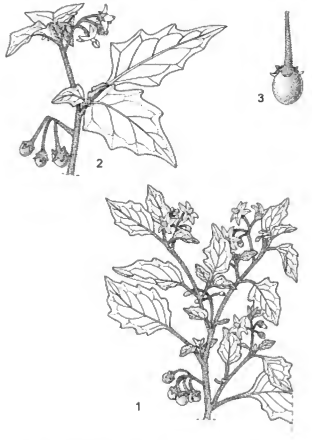
The ripe fruits are eaten in Ethiopia, Kenya, Uganda and Tanzania, where orange, yellow and red fruited types are found. *Solanum villosum* also forms an important part of traditional medicine in Africa. In Kenya, unripe fruits are used to soothe toothache. They are also squeezed on babies' gums to ease pain during teething. Leaves are used to treat stomachache and extracts from leaves and fruits are used to treat tonsillitis. Maasai boil the roots in milk and give it to children as a tonic. In Tanzania, Sukuma people apply leaves to swellings, whereas the fruit juice is used to calm sore eyes. Banyankore and Banyoro people in Uganda believe that addition of *Solanum villosum* leaves to the diet contributes to the treatment of fever associated with hypertension. Pregnant women in most parts of Kenya are encouraged to eat boiled *Solanum* leaves; people believe that they will then give birth to dark-eyed and smooth-skinned babies. It is further believed that children who eat *Solanum* vegetables cooked with milk, groundnuts or sesame rarely develop marasmus or kwashiorkor. Leaves of *Solanum villosum* are used as fodder for goats and sheep in Sudan, and for cattle and goats in Kenya.

Production and international trade *Solanum villosum* leaves are a common product at many local markets in rural and urban areas of Kenya and Tanzania. In Arusha in Tanzania *Solanum villosum* is the most expensive leafy vegetable at the urban market. No statistical data on production and trade are available.

Properties The composition of *Solanum villosum* leaves is probably comparable with that of other dark green leafy vegetables. Two alkaloids have been isolated from green fruits of *Solanum villosum*, diosgenin and solasodine, but the amount of alkaloids is lower than in *Solanum americanum* Mill.

Adulterations and substitutes In dishes *Solanum villosum* can be replaced by some other leafy vegetables from section *Solanum*, e.g. *Solanum scabrum* Mill.

Description Annual or short-lived perennial herb up to 50(–60) cm tall, much branched, unarmed; stem rounded to angled, almost glabrous to pubescent with appressed hairs. Leaves arranged spirally, simple; stipules absent; petiole 0.5–1 cm long; blade ovate to elliptical, up to 4(–8) cm × 3(–6) cm, cuneate at base and decurrent along the petiole, acute at apex, entire to sinuately or coarsely toothed, sparsely pubescent. Inflorescence an extra-axillary, umbel-like cyme, 3–5(–7)-flowered; peduncle 4–7 mm long, elongating up to 2 cm in fruit. Flowers bisexual, regular, 5-merous; pedicel 4–6(–10) mm long, becoming deflexed in fruit; calyx cup-shaped, 1–2 mm in diameter, lobes obtuse to acute or acuminate, deflexed in fruit; corolla stellate, (4–)5–8(–10) mm in diameter, white



Solanum villosum – 1, part of flowering and fruiting plant; 2, flowering and fruiting branch; 3, fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

with basal yellow-green star, lobes ovate-oblong, c. 3 mm long; stamens inserted on corolla throat, filaments 2 mm long, with hairs below, anthers connivent, 1.5–2.5 mm long, opening by terminal pores; ovary superior, globose, c. 1.5 mm in diameter, style (3–)4–5 mm long, hairy at base, stigma capitate, pale green. Fruit a globose berry 6–8(–10) mm in diameter, red, orange or yellow when ripe, many-seeded. Seeds discoid, c. 1 mm long. Seedling with epigeal germination.

Other botanical information *Solanum villosum* belongs to the subgenus *Solanum* and section *Solanum*, formerly known as section *Maurella*, or section or subsection *Morella*. Currently about 30 species are included in this section, of which 10–12 are known to occur in Africa. Research is still needed to better understand the species and their diversity within section *Solanum*. In herbaria in Africa several members of the section are lumped under *Solanum nigrum*. *Solanum villosum* has yellow, orange or red fruits whereas *Solanum nigrum* L. has black or greenish fruits when ripe. Several botanists erroneously grouped taxa with black fruits together with yellow to red-fruited taxa in *Solanum nigrum*.

Two subspecies of *Solanum villosum* have been distinguished: subsp. *villosum* and subsp. *miniatum* (Bernh. ex Willd.) Edmonds, based on hair density and presence or absence of glands on the hairs and whether the stem is rounded and smooth or angled with toothed ridges. The less hairy subsp. *miniatum* is preferred as a vegetable. However, many authors do not recognize these subspecies.

Growth and development Under optimum conditions of moisture and temperature, the seeds of *Solanum villosum* germinate within seven days. Growth of seedlings is fast and flowering starts after 5–8 weeks. Under stress, flowering can start even earlier. Vegetative growth slows down with flowering as a result of competition. *Solanum villosum* is self-pollinating and self-compatible and sets fruit easily under favourable environmental conditions. It continues flowering even when it has started fruit set, resulting in plants bearing mature fruits on the lower branches, young ones in the middle and flowers in the top part. Fruits remain on the plant and drop only when over-ripe. They are attractive to birds, rodents, lizards and rabbits, but also cattle and even humans are partly responsible for seed dispersal. Seeds can pass through the digestive system of animals without being damaged.

Ecology *Solanum villosum* occurs from sea-level to about 2400 m altitude, but it does not tolerate night frost. The optimum temperature is probably between 20–30°C. It performs well during the rainy season or when irrigated regularly, and is not resistant to drought. An annual rainfall of 500–1200 mm is suitable. *Solanum villosum* can grow on a wide range of soils, but prefers soils that are rich in organic matter and land covered with ash of recently burnt vegetation. In the wild, it is found in disturbed areas and along the edges of agricultural fields.

Propagation and planting *Solanum villosum* is mainly propagated by seed. The 1000-seed weight is about 1.0 g. Stem cuttings have also been used for propagation. Farmers collect seed from their farm or buy it at the market. Seeds from fresh fruits that have been carefully dried germinate well. In home gardens direct sowing is common; commercial farmers often use nurseries. In nurseries the seed is mixed with sand or ash, or sometimes

both, to facilitate uniform sowing. The beds are prepared by loosening the soil by hand hoe after application of decomposed manure. The beds are covered with grasses which are burnt to sterilize the soil. This also adds potash to the soil. Seed is broadcast or sown in furrows 15–20 cm apart. The seeds are covered with a thin layer of soil, but sometimes farmers prefer to leave them open so that they germinate earlier. Especially during the dry season, the beds are covered with tall grasses to maintain soil moisture. The grass is removed when the seedlings are about 3 cm tall. Nurseries require watering twice a day and careful weeding. Pest management is also important at this stage. Seedlings are transplanted when they have 6 true leaves into well-prepared and irrigated fields at a spacing of 25–30 cm × 30–40 cm. *Solanum villosum* is sometimes intercropped with other crops, e.g. maize. In this case, the seeds are direct sown, normally 3–10 per hole. If the plants have enough space, direct sowing results in taller plants with larger leaves and branches than a transplanted crop, thus producing more dry matter. For once-over harvesting. usually done when enough land is available for raising several successive crops, a dense spacing of 10 cm × 10 cm is practised.

Management *Solanum villosum* requires fairly large amounts of nutrients. A soil rich in organic matter is appropriate. Weeding is important when the plants are young, later the crop suffers little from weeds. During the dry season farmers irrigate newly transplanted seedlings twice a day, but decrease the frequency to 2–3 times per week once the plants are well established. For a good harvest of shoots and leaves, farmers often use compound fertilizer, e.g. NPK 20–10–10. In experiments in Tanzania it was shown that the maximum yield was obtained by the use of 50–100 kg N, 11 kg P and 20 kg K per ha. To improve the yield, and depending on local soil conditions, a side-dressing of 50 kg urea and 100 kg sulphate of ammonia per ha a few weeks after transplanting can be considered. In Kenya, commercial farmers prefer to use weekly foliage-sprays of fertilizer starting a week after germination until the first harvest and then after every harvest. Farmers are, however, advised not to use excessive nitrogen fertilizers as these encourage leaf diseases and build-up of nitrates, which is a health risk to consumers.

Diseases and pests Powdery mildew (*Leveillula taurica*) has been recorded on *Solanum villosum*, as well as downy mildew (*Pseudoperonospora nigrescens*). Late blight (*Phytophthora infestans*) may be problematic in cool wet highlands, but resistance to it has been found. Bacterial wilt (*Ralstonia solanacearum*) is a serious problem in Kenya and Tanzania. *Solanum villosum* is susceptible to tomato yellow leaf curl virus (TYLCV) spread by whitefly (*Bemisia tabaci*), to tobacco ringspot nepovirus (TRSV), potato U nepovirus (PVU) and probably other viruses. The crop is susceptible to root-knot nematodes (*Meloidogyne* spp.), which can be limited by crop rotation with non-susceptible crops (cereals, amaranth) and application of large amounts of organic fertilizer. Crop rotation with non-solanaceous crops is generally recommended to avoid diseases.
The greatest nuisance to *Solanum villosum* in Tanzania is black aphid *Aphis fabae*, infesting the growing points and the lower part of the leaves, making them curl, after which the plant stops growing. Caterpillars and beetles (*Lagria*, *Podagrica* and *Epilachna* spp.) and occasionally grasshoppers cause damage. Some farmers use chemical control in the nursery and in the field. Traditionally, farmers spread wood ash on the leaves, although this affects leaf quality.

Harvesting The first harvest is expected 4–5 weeks after transplanting. Harvesting for the market is done in the late evening or early morning. The stem is cut with a knife or picked by hand about 10 cm above the ground. This allows new shoots to form and is done at intervals of 7–14 days, allowing 8–10 harvests from the stock. When spacing is close (e.g. 10 cm × 10 cm) whole plants are uprooted. Flowers are removed before the produce is taken to the market.

Yield In Kenya and Tanzania the annual yield of small-scale farmers is 20–25 t/ha of leaves and young shoots; another report mentions a cumulative yield of edible leaves of 12–20 t/ha per growing season in Kenya.

Handling after harvest The harvested product is covered with banana leaves or plastic in the evening to maintain its moisture content before taking it to the market the next morning. The shoots are often tied in small bundles that are either partly immersed in water in small buckets or sprinkled with water at short intervals to keep them fresh. For use during the dry season, the leaves are harvested in large quantities, boiled in water, dried and crushed to powder.

Genetic resources Some *Solanum villosum* accessions are kept at the AVRDC Regional Center for Africa (AVRDC-RCA) in Arusha, Tanzania. In Kenya, there are several institutes that hold collections of *Solanum villosum*, and outside Africa correctly identified accessions are present at the Botanical Garden of the University of Nijmegen, Netherlands.

Breeding Some selection work on *Solanum villosum* is reported from AVRDC-RCA in Arusha, Tanzania. Artificial hybridization between *Solanum villosum* and other *Solanum* species, e.g. *Solanum scabrum* and *Solanum americanum*, may be carried out to improve productivity and resistance to diseases. These species have been reported to hybridize successfully. In Kenya and Tanzania Alpha Seed Company and Kenya Seed Company sell *Solanum villosum* seeds.

Prospects *Solanum villosum* is worth promoting as an excellent, high-value leafy vegetable and a source of income for vegetable farmers and traders in East Africa. Selection and breeding of improved cultivars with high vigour, strong resistance to pests and diseases and good consumer quality should be enhanced.

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Authors M.L. Manoko & G.M. van der Weerden

SOLENOSTEMON MONOSTACHYUS (P.Beauv.) Briq.

Protologue Engl. & Prantl, Nat. Pflanzenfam. IV, 3a: 359 (1897).

Family Lamiaceae (Labiatae)

Chromosome number $2n = 14, 26, 28$

Synonyms *Solenostemon ocymoides* Schumach. (1827).

Origin and geographic distribution *Solenostemon monostachyus* occurs from Senegal to Chad, Central African Republic, DR Congo and Angola.

Uses The leaves are eaten as a potherb, and the plant has been grown for this purpose. *Solenostemon monostachyus* has numerous medicinal uses. The leaf sap is considered sedative and stomachic and is applied internally to treat colic, convulsions, fever, headache and cough, especially in children, and externally against eyesight troubles and aphthae. Moreover, leaves are used to treat dysmenorrhoea, haematuria, female sterility, rheumatism, foot infections and snakebites. The roots are used to treat onchocerciasis (river-blindness, craw-craw). The plant has many ritual uses, especially related to pregnancy.

Properties Fresh leaves contain per 100 g edible portion: water 82.0 g, energy 230 kJ (55 kcal), protein 4.3 g, fat 0.9 g, carbohydrate 10.4 g, fibre 1.9 g, Ca 437 mg, P 109 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968).

A test with mice in Nigeria supported the use of *Solenostemon monostachyus* leaves to treat convulsions in children. The ethanolic leaf extract contains an anticonvulsant principle which depresses the central nervous system. The leaf essential oil contains β-pinene (13%), oct-1-en-3-ol (12.5%), β-caryophyllene (7%), octan-3-ol (7%) and (E,E)-α-farnesene (6%) as the major constituents.

Botany Annual or perennial, slightly succulent, aromatic herb up to 100 cm tall, branched; stem erect or decumbent, 4-angled, shortly pubescent. Leaves opposite, simple; stipules absent; petiole 1.5–4 cm long; blade ovate, 5–9 cm × 3–6 cm, cuneate at base, obtuse to acute at apex, margin crenate, puberulous and gland-dotted below, distinctly veined. Inflorescence a terminal and slender false spike up to 50 cm long, consisting of compact, sessile or shortly stalked dichasia. Flowers bisexual, zygomorphic; pedicel up to 3 mm long; calyx up to 4.5 mm long, upper tooth ovate, 2 lateral teeth shorter, 2 lower teeth almost completely or completely fused; corolla (5–)9–15 mm long, pubescent, pale bluish purple, with curved tube, 2-lipped, upper lip erect, short, lower lip boat-shaped; stamens 4, curved within the lower corolla lip; ovary superior, 4-celled, style 2-fid. Fruit consisting of 4 orbicular nutlets c. 1 mm in diameter.

Solenostemon comprises some dozens of species and occurs in Africa and Asia. It is sometimes included in *Plectranthus*. *Plectranthus* in the

strict sense differs in its calyx, of which the lower teeth are united at the base only, whereas the lateral teeth are more or less equal to the lower.
Solenostemon monostachyus is variable and has been divided into 4 subspecies, but intermediate specimens occur.

Ecology *Solenostemon monostachyus* occurs in a range of habitats. It can be found as an annual weed in anthropogenic habitats, but also as a perennial herb or even subshrub in rocky savanna.

Genetic resources and breeding *Solenostemon monostachyus* is widespread in West and Central Africa and common in many regions, and consequently not liable to genetic erosion.

Prospects *Solenostemon monostachyus* will probably remain a minor vegetable. More research on its pharmacological properties seems justified in view of its common application in traditional medicine.

Major references Berhaut, J., 1975b; Burkill, H.M., 1995; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Morton, J.K., 1962; Oden-Onu, U., 1996.

Other references Busson, F., 1965; Mve-Mba, C.E., Menut, C., Lamaty, G., Zollo, P.H.A., Tchoumbougnang, F. & Bessiere, J.M., 1994.

Authors R.H.M.J. Lemmens

SOLENOSTEMON ROTUNDIFOLIUS (Poir.) J.K.Morton

Protologue Journ. Linn. Soc. Lond., Bot. 58: 272 (1962).

Family Lamiaceae (Labiatae)

Chromosome number $2n = 64$, 84

Synonyms *Germanea rotundifolia* Poir. (1812), *Plectranthus ternatus* Sims (1824), *Plectranthus rotundifolius* (Poir.) Spreng. (1825), *Coleus dysentericus* Baker (1894), *Coleus rotundifolius* (Poir.) A.Chev. & Perrot (1905).

Vernacular names Hausa potato, frafra potato, Sudan potato, coleus potato, Zulu round potato (En). Pomme de terre de Madagascar, pomme de terre du Soudan (Fr).

Origin and geographic distribution *Solenostemon rotundifolius* originates from tropical Africa, where it is still found in the wild in East Africa. It was widely cultivated in the savanna region from Senegal to western Sudan and in South Africa, but nowadays there are only relics of former cultivation in Mali, Ghana, Nigeria and South Africa. As a crop it is now more important in tropical Asia.

Solenostemon rotundifolius – wild and planted

Uses The tasty tubers of Hausa potato are eaten as a relish with a starchy staple food, but occasionally they constitute the staple food. They are cooked with spices in various combinations with other foods such as beans and cooked vegetables. They are often roasted and people eat them whole, including their skin, as a snack. In northern Ghana farmers use them to bridge the hunger gap between planting and harvest of the main staple crops. The tubers are made into alcoholic drinks. The leaves are occasionally used as a potherb, but more often in traditional medicine, e.g. for the treatment of dysentery in Nigeria. The plant is also used to treat blood in the urine as well as eye disorders. It has various sociocultural uses. Stems from harvested plants can be used as bedding material for livestock and later turned into farmyard manure.

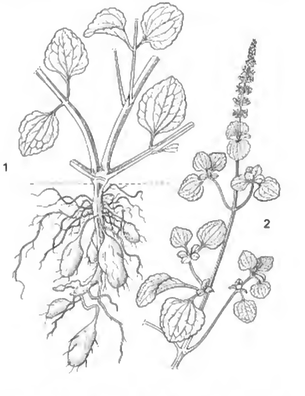
Production and international trade Hausa potato has declined considerably in importance both as a starchy vegetable and as a staple crop; it has been replaced by higher-yielding starch crops such as cassava and sweet potato. It can still be found in cultivation in the Kita region in Mali, the northern districts of Ghana, the Jos Plateau in Nigeria, and northern and eastern parts of South Africa. Production data are not available. International trade has been reported to take place between northern Ghana and Burkina Faso.

Properties The composition of the raw tubers per 100 g edible portion is: water 75.6 g, energy 394 kJ (94 kcal), protein 1.3 g, fat 0.2 g, carbohydrate 21.9 g, fibre 1.1 g, Ca 17 mg, Fe

6.0 mg, thiamin 0.05 mg, riboflavin 0.02 mg, niacin 1.0 mg, ascorbic acid 1 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968).

Description Perennial, semi-succulent, aromatic herb up to 40(–60) cm tall, branched, producing ovoid tubers up to 4(–8) cm long; stem erect to decumbent, 4-angled, shortly pubescent. Leaves opposite, simple; stipules absent; petiole 2–3 cm long; blade ovate, 2.5–8 cm × 2–5 cm, cuneate at base, obtuse to acute at apex, margin crenate-dentate, puberulous and gland-dotted below, distinctly veined. Inflorescence a terminal and slender false spike up to 15 cm long, consisting of compact, sessile dichasia. Flowers bisexual, zygomorphous; pedicel up to 1(–2) mm long; calyx campanulate, 1.5–3 mm long, glandular-hispid, upper tooth ovate, 2 lateral teeth small, 2 lower teeth almost completely fused; corolla 4–8 mm long, pubescent and gland-dotted, with curved tube, 2-lipped, upper lip erect, 4-lobed, whitish, lower lip boat-shaped, bluish purple; stamens 4, shortly united at base, curved within the lower corolla lip; ovary superior, 4-celled, style 2-fid. Fruit consisting of 4 nutlets, but rarely developing.

Other botanical information *Solenostemon* comprises some dozens of species and occurs in Africa and Asia. It is sometimes included in *Plectranthus*. *Plectranthus* in the



Solenostemon rotundifolius – 1, lower part of plant; 2, flowering branch.
Source: PROSEA

strict sence differs in its calyx, of which the lower teeth are united at the base only, whereas the lateral teeth are more or less equal to the lower.
The Hausa potato is sometimes confused with other tuber-bearing *Lamiaceae* species, particularly *Plectranthus esculentus* N.E.Br. (Livingstone potato), which differs in its cylindrical stems, elongate tubers and larger, yellow flowers, and *Plectranthus edulis* (Vatke) Agnew (Ethiopian potato), which differs in its trailing stems rooting on the nodes, irregularly shaped tubers and ascending hairy inflorescences with bright blue flowers.
Tubers of Hausa potato can be found in a diversity of shapes, sizes and colours. Types with a grey to blackish brown tuber skin are found in Mali, whereas tubers with a skin colour ranging from pale yellow to dark red are found elsewhere in Africa. There are also wild types without tubers.

Growth and development Tubers occur in clusters of 3–7, either at the base of the stem or at the nodes below the soil surface. They are ready for harvesting 150–200 days after planting by which time the plant has flowered and aerial parts have become senescent. Most tubers found in Africa are 2.5–4 cm × 1–1.5 cm, but some reach up to 8 cm. Such larger tubers are the norm in India and Sri Lanka, where yields are also higher than those in Africa's semi-arid zones.

Ecology *Solenostemon rotundifolius* occurs wild in grassland in East Africa, up to 2200 m altitude in Kenya. It is suited for cultivation in marginal areas in dry savanna with poor soils. However, tubers may not be formed when rain is insufficient. When there is too much rain, the tubers tend to branch, which is disliked by consumers because they are then difficult to peel. Hausa potato requires full sunlight and shade from other crops reduces yields. Tubers are formed with relative ease in sandy soil, but will not develop well in compacted heavy soil. Soils should be well drained as waterlogging is not tolerated.

Propagation and planting Hausa potato is normally propagated vegetatively by tubers, suckers or soft-woody stem cuttings because it produces few seeds despite the many flowers. Planting is done at the beginning of the rainy season either in mounds or ridges or in well-drained, loose soil on flat ground. In Ghana only sprouted tubers are planted with the growing end placed at the soil surface and not covered by soil. Burying will delay sprouting.

Ridges are spaced at 90 cm and plants are spaced at 15–20 cm in the ridges, resulting in a plant density of about 50,000 plants/ha. In South Africa tubers are planted at a depth of 5–10 cm with a spacing of 25 cm on ridges spaced at 75 cm. Cuttings are used occasionally and planted in pairs facing opposite directions. They are placed at a depth of 5 cm, but with the growing point clearly above the soil surface. Farmers in Ghana apply wood ash and diluted cattle urine prior to planting to promote growth and development of the crop.

Experimental in-vitro multiplication by tissue culture was successful, using stem meristems, apices and nodes.

Management Hausa potato is grown either as a sole crop or intercropped with bambara groundnut, yam, okra, millet, maize or sorghum. Because of the comparatively low yields, people hardly apply manure or fertilizer. In Ghana, however, much better yields were obtained when a liberal application of organic material was incorporated into the ridges or mounds before planting, followed by a topdressing of NPK fertilizer (e.g. NPK 16–8–8 at a rate of 125 kg/ha). When the crop is well established, earthing up with loose soil is necessary for good tuber development. Irrigation may be required during the dry season for crops planted towards the end of the rainy season. Cultivation throughout the year is possible.

Diseases and pests The incidence of pests and diseases in Hausa potato is generally low. Tuber rot, virus mottling and scab have been observed, as well as damage by termites, centipedes and potato weevils. Millipedes bore holes in the tubers. Grasshoppers and stem borers may attack the leaves. In South Africa it is believed that the crop suppresses nematode populations, but the Crop Research Institute in Kumasi, Ghana, has found that infestation by nematodes may lead to large yield losses, so that further research is needed. Where pigs roam freely these are the most serious pest.

Harvesting When the leaves and stems dry out and tubers have reached maturity, the plants are harvested with their tubers still attached by gently excavating them. The tubers are then removed and packed in baskets or sacks. Tubers left in the soil are liable to rapid decay.

Yield Tuber yields depend strongly on the amount and regularity of the rains. In Ghana, yields range between 5 and 15 t/ha when conditions are good, but are considerably lower when soil fertility or rainfall are poor. Experimental work carried out at Roodeplaat in South Africa has indicated that the potential yield could be up to 45 t/ha when adequate irrigation and plant nutrients are provided together with good agronomic practices.

Handling after harvest Hausa potato is difficult to store. Traditionally the tubers are stored in the ground under a tree where it is cooler than in the open. When stored in this way under hot conditions the special taste of Hausa potato usually lasts for two months only, after which the tubers become bland and are no longer considered a delicacy. Hausa potato is also packed in bags or baskets stuffed with straw, but if these are kept under warm conditions the tubers will soon shrivel and are no longer edible. To keep the tubers longer, people put them in pots sealed with cow dung. The small tubers needed for the next planting season are stored in this way. In cooler conditions, such as in highland regions or in South Africa, storage is easier.

Genetic resources Hausa potato has become a rare food crop in Africa. It also seems uncommon in the wild. However, there is still a wide diversity of both wild and cultivated germplasm throughout the African continent. The Vegetable and Ornamental Plant Institute, Pretoria, South Africa maintains germplasm collected in Malawi, Zambia and South Africa. A small germplasm collection is also held at the Plant Genetic Resources Centre in Bunso, Ghana. More elaborate collection of germplasm all over Africa is needed to maintain this traditional crop for future generations. Outside Africa collections are maintained at the Plant Genetic Resources Centre, Gannoruwa, Peradeniya, Sri Lanka and at the Central Tuber Crops Research Institute, Trivandrum, India.

Breeding Very little breeding work on Hausa potato has been done. Breeding to increase the size of the tuber is highly desirable. Selection in seed-propagated populations may result in productive virus-free types.

Prospects Hausa potato has good prospects as a delicate vegetable if cultural practices could be improved in combination with improved cultivars. However, as a vegetatively propagated crop it is of no interest to seed companies. Although as a starchy staple food Hausa potato cannot compete with cassava, yams and sweet potatoes, it may be of some interest for dryland regions with poor soils, where the choice of starchy crops is limited. Comparatively little is known about this crop

and research is badly needed, not only concerning cultural practice but also taking into account wild populations.

Major references Agnew, A.D.Q. & Agnew, S., 1994; Allemann, J. & Coertze, A.F., 1997; Apabol, R.R., 1997; Burkill, H.M., 1995; Codd, L.E., 1975; Jansen, P.C.M., 1996; Kay, D.E. & Gooding, E.G.B., 1987; Miège, J. & Moncousin, C., 1989; Schippers, R.R., 2000; Tetteh, J.P. & Guo, J.I., 1993.

Other references Codd, L.E., 1985; Dupriez, H. & De Leener, P., 1989; Harlan, J.R., De Wet, J.M.J. & Stemler, A.B.L., 1976; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Murdock, G.P., 1959; Tindall, H.D., 1983; van Wyk, B.E. & Gericke, N., 2000.

Sources of illustration Jansen, P.C.M., 1996.

Authors G.O. Nkansah

SONCHUS ASPER (L.) Hill

Protologue Herb. brit. 1: 47 (1769).

Family Asteraceae (Compositae)

Chromosome number $2n = 18$

Synonyms *Sonchus oleraceus* L. var. *asper* L. (1753).

Vernacular names Prickly sow thistle, rough sow thistle, spiny sowthistle (En). Laiteron épineux, laiteron rude, laiteron piquant, lastron piquant (Fr). Serralha áspera, serralha preta, serralha espinhosa (Po).

Origin and geographic distribution *Sonchus asper* is widespread in Africa (including Madagascar), Asia and Europe. In southern Africa it is widespread but infrequent. It has been introduced in the Americas and is now widespread there too.

Uses The leaves are eaten as a cooked vegetable, or occasionally raw in salads. *Sonchus asper* and *Sonchus oleraceus* L. are used in the same way and are often mixed as they are difficult to distinguish. In the Mediterranean region and South-East Asia use of *Sonchus asper* as a vegetable is widespread, in Africa its use as a vegetable is reported from Madagascar, but it is probably used elsewhere too. The latex has been used to treat warts.

Properties The leaves of *Sonchus asper* taste quite bitter and contain per 100 g edible portion: water 86 g, energy 111 kJ (27 kcal), protein 3.3 g, carbohydrate 2.0 g, fibre 3.6 g, Ca 99 mg, Mg 29 mg, P 49 mg, Fe 3.0 mg, Zn 0.9 mg, carotene 8 mg, ascorbic acid 63 mg (Guil-Guerrero, J.L., Giménez-Giménez, A., Rodríguez-García, I. & Torija-Isasa, M.E., 1998). Sesquiterpene lactones, especially of the eudesmanolide type, have been isolated from both roots and aerial parts; several of these are known to be effective against *Plasmodium falciparum*, fungi and inflammations.

Botany Annual or sometimes biennial herb up to 2 m tall; stem ridged, simple or branched. Leaves alternate, simple; blade oblanceolate, 4–30 cm × 1–9 cm, pinnately lobed with wide triangular lobes to toothed, base amplexicaul with rounded auricles, but basal leaves attenuate at base, apex acute; distal leaves smaller and less lobed. Inflorescence a stalked head, many arranged together in a lax, leafy corymb; involucre 12–14 mm long. Flowers bisexual, ligulate, yellow; corolla tube 6 mm long, ligule 4–5 mm long; stamens 5, anthers united into a tube around the style; ovary inferior, 1-celled, style 2-branched. Fruit a strongly flattened, ribbed, smooth achene up to 3.5 mm long, with white pappus 6–9 mm long. Seedling with epigeal germination; hypocotyl 0.5–1.5 cm long; cotyledons leafy, oblong-elliptical.

Sonchus comprises about 60 species, out of which 17 have been recorded in tropical Africa.

Ecology *Sonchus asper* is a weed of cultivated fields, and is also found in grassland, along lakeshores and on mud, at 750–2550 m altitude.

Management *Sonchus asper*, like *Sonchus oleraceus*, may be a host of insect pests and viral diseases that may affect crops, notably crops belonging to the *Solanaceae* and *Asteraceae* families. Harmful viruses of tomato and lettuce have been found in *Sonchus asper* in temperate regions, as well as a thrips species. Although *Sonchus asper* is a weed, it is generally not considered noxious in agriculture and horticulture.

Genetic resources and breeding As *Sonchus asper* is widespread no genetic erosion is envisaged, even though it is mostly not very abundant throughout its range.

Prospects Although possibly underutilized as a vegetable, promotion of *Sonchus asper* is not recommended because of its weedy nature.

Major references Beentje, H.J., 2000; Burkill, H.M., 1985; Decary, R., 1946; Guil-Guerrero, J.L., Giménez-Giménez, A., Rodríguez-García, I. & Torija-Isasa, M.E., 1998.

Other references Groves, R.L., Walgenbach, J.F., Moyer, J.W. & Kennedy, G.G., 2001; Helal, A.M., Nakamura, N., El-Askary, H. & Hattori, M., 2000; Hidajat, E.B., 1993; Pope, G.V., 1992; Wilken, D. & Hannah, L., 1998.

Authors C.H. Bosch

SONCHUS OLERACEUS L.

Protologue Sp. pl. 2: 794 (1753).
Family Asteraceae (Compositae)
Chromosome number $2n = 32$

Vernacular names Smooth sow thistle, annual sow thistle, common sowthistle, milk thistle (En). Laiteron potager, laiteron maraîcher, laiteron commun, lastron (Fr). Serralha branca, serralha macia, leita ruga (Po).

Origin and geographic distribution *Sonchus oleraceus* is native to Eurasia and northern Africa. It is currently a cosmopolitan weed.

Uses Throughout Africa, the primary use of *Sonchus oleraceus* is as a cooked leafy vegetable, but it is also eaten raw. The tender leaves are eaten as a salad and some people also eat the juicy root. In Uganda the Langi people first dry the leaves and later boil and mash them to be added to beans or made into a sauce that is eaten with a staple food. In Tanzania and Madagascar the roots are used as a purgative, and in Tanzania as an abortifacient and vermifuge. The use of leaf sap to treat earache (Tanzania, China, New Zealand) and deafness (western Europe) is probably effective in cases where excessive amounts of earwax are the underlying cause of the problem. The leaves are said to clear infections, are used as a sedative, stomachic, diuretic and to treat liver diseases, including hepatitis. Further medicinal uses are the treatment of eye problems (Burundi), gastritis, salmonella infection (Madagascar), kwashiorkor and anaemia (Burundi, Sudan, Uganda). In China the latex is used as a cure for opium addiction and to treat warts and cancer. For Burundi several veterinary applications are recorded (e.g. to treat diarrhoea, haematuria, vaginal prolapse). Sowthistle is a favourite food for rabbits and poultry and it is also used as fodder for cattle. The white latex is suspected of being mildly poisonous and cases of poisoning of lambs (Somalia) and horses (Australia) have been attributed to *Sonchus oleraceus*.

Properties The leaves taste mild to quite bitter. Leaves contain per 100 g edible portion: water 87 g, energy 110 kJ (26 kcal), protein 3.2 g, carbohydrate 1.8 g, fibre 3.3 g, Ca 32 mg, Mg 76 mg, P 58 mg, Fe 3.8 mg, Zn 0.8 mg, carotene 16 mg, ascorbic acid 78 mg (Guil-Guerrero, J.L., Giménez-Giménez, A., Rodríguez-García, I. & Torija-Isasa, M.E., 1998).
Callus cultures of *Sonchus oleraceus* showed broad spectrum antibacterial activity. The aqueous extract demonstrated acaricidal activity against the two-spotted spider mite, *Tetranychus urticae*. Sesquiterpene lactones, especially of the eudesmanolide type, have been isolated from *Sonchus* species.

Botany Annual or biennial herb up to 1.4 m tall; stem ridged, simple or branched. Leaves alternate, simple; blade lanceolate or oblanceolate, 4–30 cm × 1–9(–17) cm, deeply pinnately lobed with few, reflexed lobes, coarsely toothed, base amplexicaul with pointed auricles, but basal leaves attenuate at base, apex rounded or acute; distal leaves smaller and less lobed. Inflorescence a stalked head, few to many together arranged in a lax, leafy corymb or panicle; involucre 10–13 mm long. Flowers bisexual, ligulate, yellow; corolla tube 6–7.5 mm long, ligule c. 6 mm long; stamens 5, anthers united into a tube around the style; ovary inferior, 1-celled, style 2-branched. Fruit a slightly flattened, ribbed, rugose achene up to 4 mm long, with white pappus 7–8 mm long. Seedling with epigeal germination; hypocotyl 0.5–1 cm long; cotyledons leafy, oblong-elliptical.
Sonchus comprises about 60 species, of which 17 have been recorded in tropical Africa. The

Sonchus oleraceus – plant habit.
Source: PROSEA

many small light seeds of *Sonchus oleraceus* disperse readily by wind and water. Germination can take place at temperatures ranging from 7°C to over 35°C.

Ecology *Sonchus oleraceus* is mainly found in disturbed localities, including farmland, abandoned fields and recently burned fields, up to 2650 m altitude.

Management In Africa *Sonchus oleraceus* is collected from the wild and is not cultivated. It is only traded on a small scale at local markets, e.g. in Tanzania. In Indonesia it is cultivated on a small scale, and also in ancient times in Europe. The number of viral diseases it hosts is large (e.g. watermelon mosaic virus (WMV), pepino mosaic virus (PepMV), tomato spotted wilt virus (TSWV) and alfalfa mosaic virus (AMV)). *Sonchus oleraceus* further is a host for castor whitefly (*Trialeurodes ricini*), *Bemisia* whiteflies, cotton bollworm (*Helicoverpa armigera*) and the nematode *Radopholus similis*. *Sonchus oleraceus* is a preferred host for the cotton bollworm.

Genetic resources and breeding In view of its worldwide distribution and abundance there is no threat of genetic erosion and there have been no attempts to collect and maintain germplasm.

Prospects Interest from scientists in *Sonchus oleraceus* will continue to be focused on its role in crop yield reduction and as a host of diseases and pests. Monitoring and control of insect populations with this species as a trap crop offers possibilities. Medicinal and toxic properties require further investigations. As a vegetable it is likely to remain of minor importance.

Major references Andersen, R.N., 1968; Beentje, H.J., 2000; Guil-Guerrero, J.L., Giménez-Giménez, A., Rodríguez-García, I. & Torija-Isasa, M.E., 1998; Herbison-Evans, D. & Crossley, S., 2003; Katende, A.B., Ssegawa, P. & Birnie, A., 1999.

Other references Baerts, M. & Lehmann, J., 2002h; Burkill, H.M., 1985; Decary, R., 1946; Gu, H., Cao, A. & Walter, G.H., 2003; Hidajat, E.B., 1993; Khafagi-Ishrak, K., 1999; Leonard, D.B., 2003; Pope, G.V., 1992; Watt, J.M. & Breyer-Brandwijk, M.G., 1962.

Sources of illustration Hidajat, E.B., 1993.

Authors R.R. Schippers

SPINACIA OLERACEA L.

Protologue Sp. pl. 2: 1027 (1753).

Family Chenopodiaceae (APG: Amaranthaceae)

Chromosome number $2n = 12$

Vernacular names Spinach (En). Epinard (Fr). Espinafre (Po).

Origin and geographic distribution Spinach is not known in a wild state. It probably originated in northern Iran, Afghanistan and Turkmenistan where related wild species such as *Spinacia tetrandra* Steven ex M.Bieb. and *Spinacea turkestanica* Iljin can be found. It spread to China in the 7th century and to Europe in the 12th century. Spinach is now cultivated worldwide, mostly in temperate regions, but also in the cooler parts of the tropics. In tropical Africa it is grown to a limited extent in the highland areas of East and southern Africa.

Uses Spinach is an important green leafy vegetable in temperate climates. The entire above-ground part of young plants or the tops of older plants are generally consumed after light cooking. Raw spinach is sometimes eaten in salads. In Africa it is entirely a fresh market product; in western Europe and North America more than half of the produce is processed into canned or deep-frozen products.

Production and international trade In 2002 some 2.5 million t fresh spinach was produced worldwide from 170,000 ha, excluding China. The total area under spinach was 30,000 ha in Europe, 26,000 ha in Japan, 22,000 ha in Turkey and 18,000 ha in North America. The area for China alone was estimated at 590,000 ha with a production of 7.8 million t, but this probably includes several other green leafy vegetables. No statistics are available for tropical Africa, because here spinach is only grown as a home garden crop for European cuisine.

Properties Spinach contains per 100 g of fresh leaves (ribs and stems removed, 81% of the product as purchased): water 89.7 g, energy 105 kJ (25 kcal), protein 2.8 g, fat 0.8 g, carbohydrate 1.6 g, dietary fibre 2.1 g, Ca 170 mg, Mg 54 mg, P 45 mg, Fe 2.1 mg, Zn 0.7 mg, carotene 3535 μg, thiamin 0.07 mg, riboflavin 0.09 mg, niacin 1.2 mg, folate 150 μg, ascorbic acid 26 mg (Holland, B., Unwin, I.D. & Buss, D.H., 1991). In addition to a high nutritional value with respect to micronutrients, spinach is a good source of flavonoid antioxidants. It also contains oxalic acid and free nitrates, but

these are not considered harmful when average consumption is less than 100 g spinach per day.

Adulterations and substitutes In Africa Ceylon spinach (*Basella alba* L.) is a reasonable substitute for spinach. There is also a wide variety of other leafy vegetables such as amaranths and *Solanum* species.

Description Usually dioecious, glabrous annual herb up to 150 cm tall, with a long taproot. Leaves initially forming a rosette, arranged spirally on stems, simple; stipules absent; petiole 6–12 cm long; blade angular-ovate to hastate, with round to sharply pointed basal lobes, 9–30 cm × 7–20 cm, entire, pale to dark green. Inflorescence an axillary cluster, in male plants elongated and spike-like, up to 10 cm long. Flowers usually unisexual, rarely bisexual, small, greenish; male flowers with (2–)4(–5)-lobed perianth and 3–5 stamens; female flowers without perianth but with 2(–4) bracteoles becoming a hard shell tightly enveloping the fruit, ovary superior, 1-celled, stigmas 4–5(–6), thread-like. Fruit a utricle, indehiscent, teeth of envelope sometimes developing into prickles, 1-seeded. Seed dull, obtusely margined. Seedling with epigeal germination.

Spinacia oleracea – 1, habit; 2, stem with male inflorescences; 3, part of stem with prickly fruits; 4, part of stem with non-prickly fruits. Redrawn and adapted by Iskak Syamsudin

Other botanical information Many cultivar classifications exist, based on fruit and leaf characteristics. A major division is into cultivars with prickly fruits, also classified as var. *oleracea*, and cultivars with non-prickly, round fruits, also classified as var. *inermis* (Moench) Metzg. or var. *glabra* (Mill.) Moench. Cultivars are also grouped according to leaf colour (pale or dark green) and leaf texture (smooth, semi-smooth and crumpled). Asian-type spinach cultivars are fast-growing and quick-bolting, have hastate, thin and smooth leaves, long petioles which are purple-red at the base, and often prickly fruits. Leaves should be dark green according to Japanese and pale green to Chinese preferences. European and American cultivars vary from quick-growing winter/spring types with pale green, thin and smooth leaves to slow-bolting summer types with dark green, smooth to crumpled leaves; the petiole is green or pink at the base.

Examples of old open-pollinated cultivars are 'Munsterlander' (smooth leaves) and 'Bloomsdale Longstanding' (crumpled leaves). All modern cultivars are F_1 hybrids.

Growth and development Spinach is normally dioecious with almost equal proportions of male and female plants, but many gradations of monoecism and hermaphroditism are known. In horticulture, the fruit of spinach (utricle) is usually called the seed. Dry spinach seed will remain viable for 2–3 years at ambient temperatures and 5–6 years when stored at 5°C and 30% relative humidity. Depending on season and genotype, seedlings emerge 6–20 days after sowing and 35–100 days later the rosette is fully grown with the first signs of the flowering stem. Spinach is wind-pollinated. Seeds are mature about 60–70 days after flowering, when plants quickly senesce and die off.

Ecology Asian spinach cultivars, being adapted to short-day autumn or winter seasons, bolt readily in response to photoperiods of 12–14 hours. In Europe spinach is grown mostly in early spring and summer (north-western Europe) and requires a daylength of at least 14 hours for stem and flower formation. Optimum growing temperatures are 15–20°C, but spinach is tolerant of low temperatures (3°C) and even of light frost in some winter types. Vegetative growth is retarded by temperatures in excess of 27°C. In East Africa spinach cannot be grown successfully at altitudes below 1200 m. Soils should be light in texture, fertile, well-drained, rich in organic matter and with pH 6–7.5.

Propagation and planting The weight of 1000 seeds is 9–13 g. Spinach seeds are broadcast, or preferably sown in rows (5–15 cm apart) 1–3 cm deep in carefully prepared soil. Seed rates are 15–25 kg/ha for Asian-type spinach, 60–100 kg/ha for the European and American processing (deep-freezing and canning) industry, 150 kg/ha (summer) to 400 kg/ha (winter/spring) for the fresh market.

Management Control of weeds can only be carried out shortly before sowing by tillage or application of herbicides. For optimum yield and quality spinach needs high doses of N and K fertilizers as well as a regular water supply throughout the season.

Diseases and pests The most important disease is downy mildew (*Peronospora farinosa* f.sp. *spinaciae*). Control by fungicides is difficult. Host resistance to 7 physiological races is available in some modern F_1 hybrids, but a new virulent race has been found recently that is capable of overcoming this resistance. Blight, caused by cucumber mosaic virus (CMV), is especially important in warm and humid conditions; chemical control of the vector aphids (*Aphis fabae* and *Myzus persicae*) reduces incidence and some cultivars are blight tolerant. Fusarium decline (*Fusarium oxysporum* f.sp. *spinaciae*) and white rust (*Albugo occidentalis*) are particularly important in the United States. Seedling damping-off caused by *Pythium* spp. and *Rhizoctonia* spp. can be prevented by seed-dressing with fungicides. Bacterial rot (*Erwinia carotovora*) may destroy harvested spinach leaves when stored in moist and warm conditions. Pests include aphids, leaf miner (*Liriomyza* spp.) and nematodes (*Heterodera* spp. and *Ditylenchus dipsaci*).

Harvesting In Asia whole plants with 8–10 leaves are harvested, the roots are cut 1 cm below the plant base and the product is sold in bundles of 10–15 plants. In Europe and North America spinach for the fresh market is harvested by mowing the crop just above ground level at a young stage and spinach for the processing industry at the first sign of flowering stem formation.

Yield Yields vary from 10 t/ha of fresh leaves in Asia to 35 t/ha for summer crops in Europe and the United States. Seed yields are 1.5–2.0 t/ha.

Handling after harvest A spinach crop has to reach the market very soon after harvesting to be consumed as a fresh product within 2–3 days, or within 24 hours for canning or deep-freezing, to avoid loss of quality and nutritional value.

Genetic resources Working collections and germplasm of *Spinacia* spp. are present in some research centres in Europe (CGN-PGR, Wageningen, Netherlands), the United States, Japan and the Russian Federation. Recent molecular characterization has indicated that the genetic variation in these germplasm collections is not large.

Breeding Present breeding programmes aim at F_1 hybrid cultivars between highly female monoecious and highly male monoecious inbred lines. Sex expression is controlled by an X/Y heterosomal system and two strongly linked autosomal genes. The main breeding objectives depend on season, climate and preferred type: fast growth, slow bolting, high yields, round seed, leaf colour (pale or dark green) and type (smooth or crumpled), erect leaves, better heat tolerance and resistance to downy mildew, cucumber mosaic virus and other diseases.

Prospects Spinach will continue to be a very important, high-yielding and nutritious leafy vegetable in temperate climates of Europe, North America and eastern Asia. In tropical Africa it will remain only suitable for cultivation in the highlands.

Major references Correll, J.C., Irish, B.M., Koike, S.T., Schafer, J. & Morelock, T.E., 2003; Correll, J.C., Morelock, T.E., Black, M.C., Koike, S.T., Brandenberger, L.P. & Daniello, F.J., 1994; Parlevliet, J.E., 1968; Rubatzky, V.E. & Yamaguchi, M., 1997; Shinohara, S. (Editor), 1984; Sneep, J., 1982; van der Vossen, H.A.M., 1993c; Williamson, J., 1955.

Other references Bose, T.K. & Som, M.G. (Editors), 1986; De Kraker, J. (Editor), 1991; Holland, B., Unwin, I.D. & Buss, D.H., 1991; Irish, B.M., Correll, J.C., de los Reyes, B. & Morlock, T.E., 2003; Prior, R.L., 2003.

Sources of illustration Hess, H.E., Landolt, E. & Hirzel, R., 1967; Mansfeld, R., 1986; Vaughan, J.G. & Geissler, C.A., 1997.

Authors H.A.M. van der Vossen
Based on PROSEA 8: Vegetables.

STENOCHLAENA TENUIFOLIA (Desv.) T.Moore

Protologue Gard. Chron.: 193 (1856).
Family Blechnaceae

Synonyms *Lomaria tenuifolia* Desv. (1811), *Lomariopsis tenuifolia* (Desv.) H.Christ (1897), *Stenochlaena mildbraedii* Brause (1915).

Vernacular names African climbing fern, giant vine fern (En).

Origin and geographic distribution *Stenochlaena tenuifolia* occurs naturally in the coastal regions of East and southern Africa, from Tanzania to the east coast of South Africa, and Madagascar. It is also recorded from eastern Zimbabwe. *Stenochlaena mildbraedii*, which is regarded as conspecific with *Stenochlaena tenuifolia*, is present in Bioko (Equatorial Guinea), and from Cameroon to Angola and Uganda. *Stenochlaena tenuifolia* has been introduced into the United States (Florida).

Uses The young fronds (croziers, fiddleheads) are eaten in Madagascar. *Stenochlaena tenuifolia* can be used as ground cover. In Congo the sap is taken with a ripe banana as an aphrodisiac.

Properties No studies of the chemical constituents of *Stenochlaena tenuifolia* are known. A number of glycosides have been isolated from the leaves of the related *Stenochlaena palustris* (Burm.f.) Bedd., which is used as a vegetable in South-East Asia: plants from Papua New Guinea contained five flavonol glycosides (stenopalustrosides A–E) as well as a cerebroside, and several kaempferols. No alkaloids were found. The stenopalustrosides A–D showed significant activity against gram-positive bacteria.

Botany Large fern with straggling and climbing rhizome, growing high up into trees; rhizome scales sparse. Leaves up to 1.8 m long, shiny bright green, leathery, dimorphic, with pinnate sterile leaves up to 1 m long and pinnate or bipinnate fertile leaves; sterile pinnae up to about 20 pairs, up to 27 cm × 3 cm, linear, articulate with basal glands, with sharply serrate margins; fertile pinnae up to 25 cm long, divided into narrowly linear segments up to 8 cm × 0.2 cm, almost entirely covered with sporangia below. Spores reniform, colourless, monolete, with several (mostly 3) irregular raised ribs, about 40 μm × 30 μm.

Stenochlaena, which comprises 5 species and is restricted to the Old World, has been placed in a number of genera and families in the past. It seems to have affinities with *Lomariopsis* (*Lomariopsidaceae*). *Stenochlaena mildbraedii* has been regarded a second representative of the genus in Africa. It is distinguished by its pinnate fertile leaves as compared to the bipinnate fertile leaves of *Stenochlaena tenuifolia*. However, several authors have noticed the presence of both forms in a single collection (although it could not be established with certainty whether these parts originated from one individual). Electron microscope studies of the spores of the two leaf types confirmed that they are identical.

Ecology *Stenochlaena tenuifolia* is a straggling and climbing fern of the coastal swamp forest.

Management No cultivation of *Stenochlaena tenuifolia* is known, except for its use as ground cover. It does not seem to be as much of a weed as *Stenochlaena palustris* in South-East Asia, for which various studies have been carried out to control it, for instance in rubber plantations. In the United States *Stenochlaena tenuifolia* is regarded as a weed. A study in Zululand, however, indicated that it had no measurable effect on the volume growth of *Pinus elliottii* Engelm.

Genetic resources and breeding *Stenochlaena tenuifolia* does not seem to be endangered. No germplasm collections are known.

Prospects Although *Stenochlaena tenuifolia* is not as widely used as a vegetable as its sister-species *Stenochlaena palustris*, it may well be of interest. Further investigations of its cultivation, nutritional value and bactericidal properties seem justified.

Major references Bouquet, A., 1969; Bredenkamp, B.V., 1986; Decary, R., 1946; Perrier de la Bathie, H., 1936; Schelpe, E.A.C.L.E., 1970b.

Other references Ahmad Faiz, M.A., 1992; Alston, A.H.G., 1959; Dedy Darnaedi & Titien Ngatinem Praptosuwiryo, 2003; Klekowski, E.J., 1970a; Leist, N., 1975; Liu, H., Orjala, J., Sticher, O., Rali, T. & Liu, H.M., 1999; Scheepers, J.C. & Vorster, P., 1976; Verdcourt, B., 1992; Williams, R.O., 1949.

Authors W.J. van der Burg

STYLOCHAETON HYPOGEUM Lepr.

Protologue Ann. Sci. Nat., Bot. sér. 2, 2: 185 (1834).

Family Araceae

Synonyms *Stylochiton barteri* N.E.Br. (1901), *Stylochiton similis* N.E.Br. (1901).

Vernacular names Ground arum (En).

Origin and geographic distribution *Stylochaeton hypogeum* occurs from Senegal to Sudan.

Uses The inflorescences are collected from the wild and eaten in northern Ghana and Burkina Faso. People from the Tenda tribe, who live in Senegal, Guinea and Guinea Bissau, use the plant as an additive to beer. In Benin leaf decoctions of *Stylochaeton hypogeum*

are drunk to stimulate the growth of unborn infants. A decoction of the roots in combination with the bark of *Anogeissus leiocarpa* (DC.) Guill. & Perr. is used to treat haemorrhoids. In Ghana the rhizome of *Stylochaeton hypogeum* is boiled and mashed for application to boils.

Properties An aqueous extract of the root has shown anti-ulcer activity in rats.

Botany Perennial herb with underground rhizome. Leaves in tufts, simple; petiole 8–15(–25) cm long, leaf sheath marked with horizontal purple bands; blade hastate to sagittate, 10–20 cm × 5–10 cm, basal lobes narrowly triangular, (2–)3–4(–6) cm long. Inflorescence a spadix 3–8 cm long, enclosed by a spathe about equally long, partially subterranean and appearing before the leaves; spathe only opening at apex. Flowers unisexual, sessile, with cup-like perianth; male flowers in upper part of spadix, with c. 7 stamens having distinct filaments; female flowers 6–10 together in basal part of spadix, with 2–4-celled ovary, stigma large, discoid to headlike. Fruit a globose berry, several together in a subterranean, globose infructescence, few-seeded. Seed ovoid to ellipsoid, black.

Stylochaeton comprises about 17 species and is confined to sub-Saharan Africa. The orthographic variant *Stylochiton* is often used in the literature. The inflorescences of *Stylochaeton hypogeum* appear in the dry season, followed by the leaves in the rainy season.

Ecology *Stylochaeton hypogeum* grows in open forest, shrub vegetation and savanna, on sandy or sandy clay soils, also in flood plains.

Genetic resources and breeding *Stylochaeton hypogeum* does not seem to be endangered, despite its use as a vegetable and medicine. Both uses are limited and collection of the plants does not occur at a large scale.

Prospects The medicinal properties and chemical composition of *Stylochaeton hypogeum* and related species are virtually unknown and in need of investigation.

Major references Adam, J.G., 1966b; Adjanohoun, E.J., Adjakidjè, V., Ahyi, M.R.A., Aké Assi, L., Akoègninou, A., d'Almeida, J., Apovo, F., Boukef, K., Chadare, M., Cusset, G., Dramane, K., Eyme, J., Gassita, J.N., Gbaguidi, N., Goudote, E., Guinko, S., Houngnon, P., Lo, I., Keita, A., Kiniffo, H.V., Kone-Bamba, D., Musampa Nseyya, A., Saadou, M., Sodogandji, T., De Souza, S., Tchabi, A., Zinsou Dossa, C. & Zouhon, T., 1989; Burkill, H.M., 1985; Burkill, H.M., 2000; Ferry, M.P., Gessain, M. & Gessain, R., 1974.

Other references Lemordant, D., 1971a; Lemordant, D., 1971b; Mertz, O., Lykke, A.M. & Reenberg, A., 2001; Vanden Berghen, C., 1988.

Authors W.J. van der Burg

TALINUM CAFFRUM (Thunb.) Eckl. & Zeyh.

Protologue Enum. pl. afric. austral.: 282 (1836).

Family Portulacaceae

Origin and geographic distribution *Talinum caffrum* is found from southern Ethiopia south to Namibia, Botswana and South Africa.

Uses The leaves of *Talinum caffrum* are collected from the wild and eaten raw as a salad or as a cooked vegetable. They contain much water and are also eaten raw against thirst. Occasionally, *Talinum caffrum* is cultivated as an ornamental, succulent potplant.

Properties The nutritional composition of *Talinum caffrum* leaves is not known, but it is probably comparable to that of *Talinum triangulare* (Jacq.) Willd.

Botany Perennial, rather succulent herb with a deeply buried tuber; stems annual, usually decumbent or prostrate, up to 40 cm long, much branched. Leaves alternate, simple; petiole 1–3 mm long; blade linear to narrowly elliptical, 2–8 cm × 3–13 mm, base cuneate, apex apiculate, margin often revolute. Flowers usually solitary in leaf axils, bisexual, opening in the afternoon; stalk consisting of 2 parts, lower part (peduncle) up to 2.5 cm long, tipped by a pair of bracts, upper part (pedicel) 1–2 cm long, stout, thickened upwards, recurving in fruit; sepals 2, lanceolate, 0.5–1.5 cm long; petals 5, spreading, obovate to elliptical, c. 1 cm long, yellow; stamens 25–60; ovary superior, style slender, 2–4 mm long, stigma 3-branched. Fruit a conical capsule 0.5–1 cm long, glossy yellow, 3-valved, the valves falling separately, many-seeded. Seeds lens-shaped, up to 2 mm in diameter, glossy black, with prominent concentric ridges.

Talinum comprises about 40 species, most of them found in Mexico and southern United States, and 7 species in tropical Africa. *Talinum caffrum* belongs to a complex of 4 closely related species characterized by a deeply buried tuber from which annual stems arise, alternate leaves, yellow flowers in axillary few-flowered cymes, opening in the afternoon, spreading petals and a hard and tough fruit with glossy black seeds. The other species of

the complex are *Talinum arnotii* Hook.f., *Talinum crispatulum* Dinter and *Talinum tenuissimum* Dinter. All 4 species are similarly used and identification is particularly difficult when seed is lacking. The complex is centred in the Kalahari region in southern Africa, where the species are more distinct than further north in East Africa.

Ecology *Talinum caffrum* is found in dry open places in short grassland and among rocks, from sea-level up to 2000 m altitude. Because of its large tuber, it is drought resistant.

Genetic resources and breeding *Talinum caffrum* is widespread and not in danger of genetic erosion. There are no known germplasm collections.

Prospects *Talinum caffrum* will remain a minor vegetable in drier areas, where it usually still produces leaves when other vegetables are scarce.

Major references Phillips, S.M., 2002; Tölken, H.R., 1969; van Wyk, B.E. & Gericke, N., 2000; Williamson, J., 1955.

Other references Gilbert, M.G., 2000; Wild, H., 1961a.

Authors P.C.M. Jansen

TALINUM PANICULATUM (Jacq.) Gaertn.

Protologue Fruct. sem. pl. 2: 219 (1791).

Family Portulacaceae

Chromosome number $2n = 24$

Synonyms *Talinum patens* (L.) Willd. (1799).

Vernacular names Flameflower, jewels of Opar (En). Herbe onze heures (Fr). Lingua de vaca, beldroega miúda, maria gombi (Po).

Origin and geographic distribution *Talinum paniculatum* is native to tropical America, but is now a pantropical weed. It occurs scattered throughout tropical Africa, and is locally cultivated as a vegetable in Ghana and Nigeria.

Uses The shoots and leaves of *Talinum paniculatum* are added to stews and soups, e.g. in Ghana, Nigeria and DR Congo. They are also eaten as a vegetable in tropical America. *Talinum paniculatum* is cultivated as a garden ornamental and potplant.

Properties There is no information on the nutritional composition of *Talinum paniculatum* leaves, but it is probably comparable to that of *Talinum triangulare* (Jacq.) Willd.

Adulterations and substitutes Leaves of *Talinum paniculatum* may be replaced by those of *Talinum triangulare*, which have a similar but slightly less sharp taste.

Botany Erect, glabrous perennial herb up to 100(–120) cm tall, not branched or sparsely branched at base; roots swollen and fleshy; stem succulent, slightly woody at base, dark purple to brownish black. Leaves alternate, simple, almost sessile, succulent; stipules absent; blade elliptical to obovate, 3–12 cm × 1.5–5 cm, base cuneate, apex acute, entire, venation pinnate, indistinct. Inflorescence a large, many-flowered terminal panicle up to 40(–60) cm long. Flowers bisexual, regular, c. 1 cm in diameter; pedicel c. 1 cm long, slender; sepals 2, rounded, 1–2 mm long; petals 5, free, obovate to orbicular, pink; stamens 15–20; ovary superior, 1-celled, style slender, with 3-branched stigma. Fruit a globose capsule 3–5 mm long, 3-valved, elastically dehiscent, many-seeded. Seeds lenticular to reniform, c. 1 mm long, smooth or tuberculate, shining black.

Talinum comprises about 40 species, most of them found in Mexico and southern United States, and 7 species in tropical Africa.

Ecology In tropical Africa *Talinum paniculatum* occurs locally naturalized, usually in cultivated land and roadsides, sometimes in forest edges, up to 2200 m altitude. In cultivation it prefers well-drained, moist soil rich in organic matter, and full sun. It is drought and shade tolerant.

Management *Talinum paniculatum* is mainly collected from the wild, but is cultivated in Ghana and southern Nigeria. It is propagated by seed or cuttings. There are about 5000 seeds per g. Seeds are sown in the field under light shade or in a nursery. Seedlings appear after 1 week and should be transplanted within 5 weeks. Cuttings are taken from slightly woody stems, from which tops and leaves are removed. They require ample watering. Cuttings are planted at a density of about 5 per m². The crop responds well to fertilizer.

A first harvest can be taken about 6 weeks after planting cuttings, or 8–9 weeks after sowing. Young shoots are picked when the plants are 30 cm tall and leaves are fully developed. Inflorescences should be removed regularly. Although plants remain productive longer, they should be removed after one year as they become woody.

Genetic resources and breeding *Talinum paniculatum* is widespread and not in danger of genetic erosion. A few accessions are held at the National Germplasm Resources Laboratory, Beltsville, Maryland, United States.

Prospects In tropical Africa *Talinum paniculatum* is currently mainly collected from the wild. It is poorly known, but deserves more attention as it is easy to grow and productive.

Major references Bola, M. & Szafranski, F., 1991; Mosango, M. & Isosi, W., 1998; Phillips, S.M., 2002; Steyn, E.M.A. & Smith, G.F., 2001; van Epenhuijsen, C.W., 1974.

Other references Burkill, H.M., 1997; Mosango, M., Maganyi, W. & Namaganda, M., 1999; Mosango, M., Maganyi, W. & Namaganda, M., 2001; Schippers, R.R., 2002a; Shimoda, H., Nishida, N., Ninomiya, K., Matsuda, H. & Yoshikawa, M., 2001.

Authors M. Mosango

TALINUM PORTULACIFOLIUM (Forssk.) Asch. ex Schweinf.

Protologue Bull. Herb. Boiss. 4, app. 2: 172 (1896).

Family Portulacaceae

Chromosome number $2n = 24$

Synonyms *Talinum cuneifolium* (Vahl) Willd. (1800).

Origin and geographic distribution *Talinum portulacifolium* occurs from Nigeria east to Ethiopia and Eritrea, and south to northern South Africa; it also occurs in Arabia and India. In Africa it is occasionally cultivated.

Uses The leaves of *Talinum portulacifolium* are eaten as a cooked vegetable or raw as a salad, alone or with young stem parts. In Tanzania leafy stem parts are often cooked together with *Bidens* or *Cleome* leaves, or mixed with coconut milk or pounded groundnuts and eaten with the staple food. The leaves can also be stored dry for later use. The plant is a palatable fodder for cattle and goats. In Ethiopia the leaves are applied medicinally against eye diseases and the root against cough and gonorrhoea. In Tanzania the plant is credited with aphrodisiac properties and a leaf decoction is used as a remedy for constipation.

Properties The nutritional composition of *Talinum portulacifolium* leaves is not known, but probably it is comparable to *Talinum triangulare* (Jacq.) Willd.

Botany Perennial herb with grey, succulent stems up to 1(–3) m long, sprouting from a thickened root. Leaves alternate, simple, slightly fleshy; petiole 2–3 mm long; blade broadly obovate to oblong, 2–8 cm × 1–3.5 cm, base cuneate, apex rounded but apiculate, margin entire. Inflorescence a terminal panicle with lateral cymes on a central axis up to 30 cm long. Flowers bisexual, regular, opening towards the evening, 2–2.5 cm in diameter; pedicel 1–2 cm long, recurving in fruit; sepals 2, ovate, 4–5.5 mm long, concave; petals 5, obovate, usually magenta, sometimes red, pink or white; stamens c. 25; ovary superior, style slender, c. 1.5 mm long, ending in a 3-branched stigma. Fruit a globose capsule up to 7 mm in diameter, bright yellow, 3-valved, the valves falling separately, many-seeded. Seeds lens-shaped, c. 1 mm in diameter, glossy black, smooth or papillose.

Talinum comprises about 40 species, most of them found in Mexico and the southern United States, and 7 species in tropical Africa. *Talinum portulacifolium* is sometimes confused with *Talinum triangulare*, which is also used as a vegetable. The latter species differs in its pink flowers arranged in cymes on triangular stalks, sepals prominently 3-veined and tuberculate seeds.

Ecology *Talinum portulacifolium* is common in a wide range of habitats, from rocky locations to grassland, in open bushland and thickets, along water courses and as a weed in fields, from sea-level up to 2200 m altitude.

Management *Talinum portulacifolium* is mostly collected from the wild and only occasionally cultivated. Propagation is by seed and cuttings.

Genetic resources and breeding *Talinum portulacifolium* is widespread and not in danger of genetic erosion. There are no known germplasm collections.

Prospects *Talinum portulacifolium* will remain a minor vegetable, of local importance when other vegetables are scarce.

Major references Burkill, H.M., 1997; Nyananyo, B.L.O. & Olowokudejo, J.D., 1986; Phillips, S.M., 2002; Ruffo, C.K., Birnie, A. & Tengnäs, B., 2002.

Other references Gilbert, M.G., 1993c; Gilbert, M.G., 2000; Hauman, L., 1951b; Jansen, P.C.M., 1981; Tölken, H.R., 1969; Wild, H., 1961a.

Authors P.C.M. Jansen

TALINUM TRIANGULARE (Jacq.) Willd.

Protologue Sp. pl. 2: 862 (1799).

Family Portulacaceae

Chromosome number $2n = 24, 48, 72$

Synonyms *Talinum fruticosum* auct. non (L.) Juss.

Vernacular names Waterleaf, talinum, Ceylon spinach (En). Grassé, pourpier tropical (Fr). Beldroega grauda, lustrosa grande (Po).

Origin and geographic distribution Waterleaf is a cosmopolitan weed common throughout the humid tropics. It has been recorded for several countries in West and Central Africa. It is claimed to have a South American origin, but an African origin may also be possible, as several *Talinum* species including the closely related *Talinum portulacifolium* (Forssk.) Schweinf. occur in Africa. Waterleaf is eaten as a vegetable throughout the tropics including many countries in West and Central Africa; it is cultivated in Nigeria and Cameroon.

Uses The leaves are used in the preparation of slightly slimy soups and stews to complement the starchy main dish. In southern Nigeria, where it is called 'gbure', it is commonly mixed in soups with Jew's mallow (*Corchorus olitorius* L.). Pepper and some dry fish and meat are often added to improve the taste and nutritional qualities of the sauce. Waterleaf sauce may also be a mixture of tomatoes, onion and waterleaf to which palm oil and salt are added. In Cameroon, where it is called 'bolki' or 'belok-sup', waterleaf combined with eru (*Gnetum* leaves) and fufu (starchy dish) is considered a delicacy; the tender shoots of waterleaf soften the tough leaves of eru. In Nigeria waterleaf is collected from the wild during the dry season when other more popular vegetables are scarce and expensive. The collection of waterleaf from the wild is a good source of income for poor farmers. The leaves are also eaten raw in salads. Waterleaf is used as a colouring agent in okra soup.
In Cameroon, waterleaf is used as a treatment

Talinum triangulare – wild and planted

for measles, whereas in Assam (India), it is used to treat diabetes. In Indonesia a tonic is made from the fleshy root. In experiments waterleaf performed well as a fodder for raising giant snails.

Production and international trade Waterleaf was long considered a vegetable for the poor and was thus not highly valued. Since the increased popularity of eru (*Gnetum* leaves) in Cameroon and eastern Nigeria from around 1990 onwards, the demand for waterleaf has steadily risen. It is now a common product on local markets, but no data on production and trade are available.

Properties The leaves contain per 100 g edible portion: water 90.8 g, energy 105 kJ (25 kcal), protein 2.4 g, fat 0.4 g, carbohydrate 4.4 g, fibre 1.0 g, Ca 121 mg, P 67 mg, Fe 5.0 mg, thiamin 0.08 mg, riboflavin 0.18 mg, niacin 0.3 mg, ascorbic acid 31 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). The vitamin A content is comparable to other medium green leafy vegetables, about 900 μg.
Waterleaf is a mucilaginous vegetable with high oxalate content. The presence of oxalate is a drawback since more than 90% of it is present in soluble form and can induce kidney stones if taken in excess. Blanching or cooking removes nearly half of the soluble oxalate. Waterleaf also contains hydrocyanic acid, which is a further reason why this vegetable should be consumed in small quantities only and why it is not recommended for livestock. Caution should be exercised in the use of this vegetable in infant foods, the more so since it contains nitrates and nitrites, which are not removed by cooking. Waterleaf is rich in saponins.

Adulterations and substitutes In most dishes waterleaf can be replaced by *Basella alba* L. or any other watery slimy leafy vegetable.

Description Erect, glabrous perennial herb up to 80(–100) cm tall, usually strongly branched; roots swollen and fleshy; stem succulent, obtuse-angular to terete. Leaves alternate, simple, almost sessile, succulent; stipules absent; blade obovate to spatulate, 3–15 cm × 1–6 cm, base long-tapering, apex rounded to notched, mucronate, entire, venation pinnate, indistinct. Inflorescence a terminal cyme on a triangular stalk up to 12 cm long. Flowers bisexual, regular; pedicel c. 1 cm long, recurving in fruit; sepals 2, free, with 3 prominent veins; petals 5, free, obovate, up to 1 cm long, pink; stamens numerous; ovary superior, 1-celled,

Talinum triangulare – 1, flowering and fruiting shoot; 2, flower in longitudinal section; 3, pistil (ovary in longitudinal section); 4, fruit; 5, seed. Source: PROSEA

style slender, with 3-branched stigma exceeding stamens. Fruit a globose to ellipsoid capsule 4–7 mm long, 3-valved, elastically dehiscent, many-seeded. Seeds compressed globose-reniform, c. 1 mm long, tuberculate, shining black.

Other botanical information *Talinum* comprises about 40 species, most of them found in Mexico and southern United States, and 7 species in tropical Africa. *Talinum triangulare* is sometimes confused with *Talinum portulacifolium*, but the latter differs by its paniculate inflorescence with terete axis, sepals not prominently veined and smooth seeds.

Growth and development The onset of flowering does not appear to affect leaf or shoot production. Plants take 40–75 days to flower from stem planting, and at flowering they have 4–9 branches and 25–90 leaves. Waterleaf is recorded as being self-pollinated with a limited degree of out-crossing. Fruiting takes 75–80 days from stem planting. Under natural conditions, plants will live for 4–6 months. Waterleaf is relatively tolerant to drought. Exposed to drought it adopts a crassulacean acid metabolism (CAM), resulting in an effective use of available moisture, carbon dioxide assimilation continuing during the night and increased growth.

Ecology Waterleaf grows best under humid conditions at temperatures of about 30°C. Growth is very fast during the rainy season but will slow down considerably during the dry season. It grows well under shade and in cloudy weather. It can grow in fully exposed localities, but there plants remain smaller. Growth is most profuse when the water content of the soil is close to field capacity. High tem35°C) and drought negatively affect the number of leaves, leaf area, stem size, and number of branches.

Propagation and planting Waterleaf can be sown, planted or collected from the wild. Commercially, it is mostly grown through cuttings 10–15 cm long. It is advisable to remove the lowest pair of leaves before planting. In Cameroon and Nigeria, the first planting usually takes place in November. Waterleaf may also be propagated by seed. Seeds are tiny (the 1000-seed weight is about 0.25 g) and can only be collected from fruits which have turned yellow. However, collection of seeds from mature fruits is difficult as they shatter when touched. Green fruits will not yield viable seeds, but nearly mature fruits, that do not yet readily dehisce, yield seed that has an acceptable germination rate after proper drying. The seeds are thoroughly mixed with fine dry sand and the mixture is broadcast in a well-prepared nursery bed. Germination takes place after about 5 days and subsequent growth is very rapid if adequate water is supplied. Seedlings can be transplanted when 3 weeks old. Waterleaf is frequently intercropped with other vegetables. Alternatively, it can be grown as a sole crop at a spacing of about 15 cm × 15 cm. A close spacing reduces competition from weeds and is possible because pressure from diseases is limited. In fertile soils or with adequate fertilizer spacing may be increased to 25 cm × 25 cm.

Management After planting, watering is required daily during the first week, and three times per week when the plants have covered the soil completely. Waterleaf needs much nitrogen; yellowing of leaves indicates lack of nitrogen. It may be fertilized with household waste, dung or mineral fertilizer. Nitrogen may be applied at intervals of 2–3 weeks to stimulate leaf development.

Waterleaf can be a weed in cultivated or disturbed land, including roadsides and near

homesteads, but few farmers worry about it since its roots are shallow and the plant is easy to remove.

Diseases and pests Waterleaf is one of the few vegetables that are hardly affected by pests or diseases. The most common diseases are white leaf spot (*Pleospora* spp.) and leaf mosaic caused by an unknown virus. A so-far unidentified blight causes dark-green spots on the underside of the leaves. The spots later turn brown or reddish on the upper side of the leaves and eventually become black, rendering the shoots unsaleable. There is no known treatment other than eliminating affected plants at an early stage. Waterleaf is a host of root-knot nematodes (*Meloidogyne* spp.).

Harvesting It takes only 3 weeks from planting until the first harvest can take place. Thereafter, shoots can be harvested at 1–2 week intervals for a period of two months. Leaf size decreases with increasing plant age and number of harvests. The first 1–3 harvests provide the best leaf quality for marketing. On average, farmers can harvest 4 times from a plant before its growth starts to decline. The best way to harvest a crop is by cutting the stem just above ground level. This allows faster regeneration than harvesting only the upper portion and side shoots. When the first harvest is delayed and the lower parts of the stem are becoming brown and have dropped their leaves, it is still advisable to cut just above the ground in order to obtain a better quality for the next harvest. A crop planted by cuttings is best harvested by cutting the new side shoots. A few weeks after the start of the rainy season, wild plants will be offered at the market at highly competitive prices and at this stage cultivation is no longer feasible, especially when labour has to be paid for. A rain-fed crop can remain in the field for 60–180 days.

Yield The yield range is 10–60 t/ha.

Handling after harvest Waterleaf is highly perishable and the shoots may start withering only a few hours after being harvested. This is not a problem when people wish to dry the product, but it is no longer suitable as a fresh marketable vegetable. It is possible to store the shoots in a plastic bag in a refrigerator for several days.

Genetic resources No collections of germplasm of *Talinum triangulare* are known to be maintained. There seems to be no risk of genetic erosion because it is widespread and has a weedy habit.

Breeding Accessions collected in Nigeria and Cameroon showed very limited diversity and it was not found worthwhile to select lines that could be developed into distinct cultivars. In Nigeria the green type is most common, but occasionally plants with varying degrees of purple colouration in leaves and stems have been found in the south-eastern part of the country, where waterleaf is often cultivated.

Prospects Waterleaf is a productive, nutritious and easy-to-grow vegetable. With expanding commercial production, waterleaf could become a source of income for a limited number of farmers and traders. Introducing waterleaf in new areas is not recommended because it can easily become a weed.

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Sources of illustration Rifai, M.A., 1993.

Authors D.A. Fontem & R.R. Schippers

TELFAIRIA OCCIDENTALIS Hook.f.

Protologue Oliv., Fl. trop. Afr. 2: 524 (1871).

Family Cucurbitaceae

Chromosome number $2n = 22, 24$

Vernacular names Fluted pumpkin, fluted gourd (En). Courge cannelée (Fr).

Origin and geographic distribution Fluted pumpkin occurs in the forest zone of West and Central Africa, most frequently in Benin, Nigeria and Cameroon. It is a popular vegetable all over Nigeria. It is rare in Uganda, and absent in the rest of East Africa. It has been suggested that it originated in south-east Nigeria and was distributed by the Igbos, who have cultivated this crop since time immemorial. It is, however, equally possible that fluted pumpkin was originally wild throughout its current range, but that wild plants have been harvested to local extinction and are now replaced by cultivated forms.

Uses The main use of *Telfairia occidentalis* is as a leaf and seed vegetable. The tender

Telfairia occidentalis – wild and planted

shoots, succulent leaves and immature seeds are cooked and consumed as a vegetable. The leaves are used alone or together with okra (*Abelmoschus caillei* (A.Chev.) Stevels and *Abelmoschus esculentus* (L.) Moench), dika nut (*Irvingia gabonensis* (Aubry-Lecomte ex O'Rorke) Baill.), or egusi seeds (*Citrullus lanatus* (Thunb.) Matsum. & Nakai and other species). They can also be mixed with eru (*Gnetum africanum* Welw.) and *Pterocarpus soyauxii* Taub. They are often cooked with fish, meat and tapioca. Immature seeds are cooked or roasted. Seeds can also be fermented for several days and eaten as a slurry. The fruit pulp with young seeds is occasionally made into marmalade. Mature seeds are not consumed directly because they have a high content of antinutrients, but their fat and oil may be extracted. The seed cake is suitable for fortifying foods and the seed oil serves as cooking oil and for making margarine. The oil can also be used as drying oil for paints and varnishes, although it is also reported to be non-drying. The raw flour shows better water- and fat absorption properties than the oil, hence its useful application in baking products and ground-meat products. The rind and pulp of the fruit of fluted pumpkin are used as fodder for livestock. Pregnant women and patients suffering from anaemia use leaf juice to strengthen the blood. The stems are macerated to produce fibres that are used as a sponge.

Production and international trade Fluted pumpkin leaves are common in the markets of lowland areas in Benin, Nigeria and Cameroon. During the dry season in Nigeria intensive trade develops in areas along river banks for sale to urban areas where major food-crop markets develop. In Nigeria the leaves are also transported by road from the south over a long distance to the big cities in the north. The cultivation of fluted pumpkin is developing around cities as a way of reducing the high transportation costs. No statistical data are available on the total production. In Nigeria demand from different parts of the country has raised the price of the leaves and fruits. The average price per fruit in Nigeria is US$ 0.70–1.00 (2002).

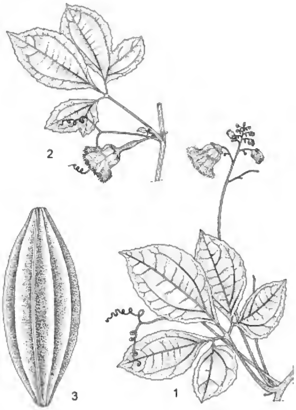
Properties The moisture content and composition of the leaves show large variations as a function of cultivar, plant age, ecological conditions and cultural practices. The composition of the leaves is comparable to that of other dark green leaf vegetables. The leaf composition per 100 g edible portion is: water 86.4 g, energy 147 kJ (47 kcal), protein 2.9 g, fat 1.8 g, carbohydrate 7.0 g, fibre 1.7 g. The high content of mineral nutrients, especially of Mg, Fe and K, and of carotene and vitamin C make the leaves potentially useful as food supplements. Young leaves contain the antinutrients cyanide at 60 mg per 100 g dry matter and tannins at 41 mg per 100 g dry matter, but their concentrations are below toxic levels and may not affect the bioavailability of the minerals. Young leaves should be well cooked to remove the potential toxic effects before consumption.

The composition of the seed per 100 g edible portion is: water 6.2 g, energy 2280 kJ (543 kcal), protein 20.5 g, fat 45.0 g, carbohydrate 23.5 g, fibre 2.2 g, Ca 84 mg, P 572 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). Other sources recorded a protein content of 28–37% and an oil content of 42–56% of the dry matter. The mineral content of the seed is reported to be high. The seeds are high in essential amino acids (except lysine) and can be compared with soya bean meal with 95% biological value. The fruit pulp has a protein content of about 1.0%.

The main constituents of the seed oil are oleic acid (37%), stearic and palmitic acid (both 21%), linoleic acid (15%). Variation between samples, however, is large.

Adulterations and substitutes Fluted pumpkins as a leafy vegetable may be replaced by other dark green leafy vegetables.

Description Perennial, dioecious herb climbing by coiled, often branched tendrils to a height of more than 20 m; root system ramifying in the top surface of the soil; stem angular, glabrous, becoming fibrous when old. Leaves arranged spirally, pedately compound with 3–5



Telfairia occidentalis – 1, part of male flowering plant; 2, part of female flowering plant; 3, fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

leaflets; stipules absent; petiole (2–)4–11(–15) cm long; leaflets with petiolules 0.5–3.5 cm long, central one largest, up to 15(–19) cm × 10(–12) cm, lateral ones asymmetrical, usually dentate in the upper two-thirds, sometimes scabrid underneath, 3-veined from near the base. Male inflorescence an axillary raceme up to 3(–5.5) cm long, on a peduncle up to 25 cm long, with at base of peduncle one long-pedicellate flower flowering long before the others; female flowers solitary in leaf axils. Flowers 5-merous, cream coloured, pedicel up to 4 cm long, receptacle campanulate, sepals triangular, up to 5 mm long, petals free, oblong, fringed; male flowers with 3 stamens, two 4-locular and one 2-locular, with large reddish connective; female flowers similar to male flowers but with inferior, cylindrical, 3-celled ovary and 3 large, heart-shaped stigmas. Fruit a drooping, ellipsoid berry 40–95 cm × 20–50 cm, weighing up to 6 kg, with 10 prominent ribs, pale green and covered with white bloom wax, fruit pulp yellow, many-seeded. Seeds compressed ovoid, up to 4.5 cm long, black or brown-red. Seedling with hypogeal germination, developing first a taproot and then numerous, spreading axillary roots; epicotyl 5–12 cm long; cotyledons planoconvex, fleshy.

Other botanical information *Telfairia* is classified in the tribe *Joliffieae* of the subfamily *Cucurbitoideae*. It comprises 3 species, of which *Telfairia pedata* (Sm. ex Sims) Hook. (oysternut) is much cultivated for its seed oil in East Africa. The names *Telfairia pedata* and oysternut are often used erroneously for *Telfairia occidentalis*.

Cultivars of *Telfairia occidentalis* are distinguished by seed colour, thickness of vine, size of leaf, growing vigour, days to flowering and succulence. In Nigeria the two main cultivars are 'ugu-ala', characterized by succulent, broad leaves, small black seeds, thick stem and slow growth, and 'ugu-elu' which has a high growth rate, large brownish seeds with high viability, and thin stem with small leaves. The large succulent leaves of 'ugu-ala' make this cultivar a commercial vegetable in high demand, while the fast emergence and high growth rate of 'ugu-elu' is preferred by farmers because of quick returns. The seed is often polyembryonic, which is useful for multiplication and in breeding.

Growth and development Seed size affects vigour, germination and seedling establishment. The viability varies from 63% for small seed (<11 g), up to 89% for the largest seeds 22 g). Germination takes about 14 days in natural soil, but only 7 days in a sawdust medium. Vine length one week after emergence is on average 31 cm for large seeds, whereas small size seeds grow into a corresponding vine length of 16 cm. Larger seeds also show better growth potential in terms of number of leaves and number of branches, and show more uniformity in the seedling stand. The vegetative growth pattern of plants is sigmoidal and reaches its peak 6.5 months after planting under selective and periodic pruning of edible young leaves. Male plants flower about 3 months after planting, a month earlier than females ones. Flower opening starts from the base of the inflorescence. Male flowers have a noticeable scent around noon when pollinating insects, mostly bees of the genus *Trigona*, visit the flowers. The stigma of female flowers is receptive in the afternoon. Hand pollination seems to be advantageous for fruit set as it resulted in 35% fruit set compared to 15% fruit set in open pollination. Fruit set is evidenced by a rapid growth of the ovary starting within

3 days after pollination. Fruit growth is sigmoidal over 8 weeks; growth is rapid between 1.5–5.5 weeks after successful fruit set. A white, waxy bloom develops on the surface of fruit a week after fruit set and gradually intensifies, but at maturity it becomes less intense. The maturing fruit sometimes suppresses fruits that set later. Female plants produce about 18 single flowers which set fruit, but only 1–4 develop into mature fruits. Out of the female plants of a population, only 35% bear fruits. A large variation occurs between and within plants in the number of seeds per fruit, from 6 seeds per fruit up to 196, with an average of 62 seeds. The seeds are also unequal in size, varying from 1 g to 68 g. Some seeds exhibit polyembryony. The seed is recalcitrant in nature and thus seed storage is difficult. The time to physiological maturity of the fruit is 9 weeks after fruit set.
Identifying the female plants from either seeds or young seedlings has not been successful, but vine size 64 days after planting could be used as a sex indicator, because female plants are more vigorous than the male ones.

Ecology In the wild, fluted pumpkin occurs in forest fringes and secondary forest, possibly often as a relic of former cultivation. Fluted pumpkin grows fast in the warm humid tropics, producing edible leaves in the rainy season and at the beginning of the dry season, for a period of 6–10 months. In traditional agriculture, it is a rainfed crop and water deficiency during the dry season reduces its productivity. Although it is fairly drought tolerant, rainfall appears to be the major factor in its productivity. The best leaf and fruit yield and highest plant survival rate occur when the plants are irrigated 2–3 times per week during the dry season. Fluted pumpkin can be grown under a wide range of soil conditions. It can be managed as a short-term perennial when grown on well-drained soils, slightly shaded and mulched. On soggy soils and in sunlit spots it can only be grown as an annual.

Propagation and planting Fluted pumpkin seeds are viviparous (germinating in the fruit). Since seeds are recalcitrant they cannot be stored for more than 3 days once they are extracted from the fruit. The critical seed moisture content below which seeds cannot recover from desiccation is 40–60%. Fluted pumpkin is often grown as a crop in homesteads where it is intercropped with other vegetables and food crops such as cassava, yams and maize, or planted against fences. Commercially it is grown as a sole crop. The conventional method of propagation is by seed, sown directly at a rate of 30,000–70,000 seeds/ha and spaced at 0.3–1 m × 0.3–1 m. Densely spaced stands are best for leaf production, while the wider spacing is best for fruit production when staked. Depending on the soil type, rainfall and cropping pattern, fluted pumpkin can be planted on the flat, or on ridges or mounds.

Management During the rainy season, staking is commonly practised to reduce disease infection. Plants are staked individually or, for fruit production, with bamboo trellis. During the dry season staking is not needed for crops for leaf production because there is less disease attack. Staking does not have a significant effect on the yield of leaves. Because of the prolific nature of the plant, weeds are not troublesome. Planting on flat land is the best method of weed suppression. Three weedings may be required in a staked crop during the rainy season. During the dry season when plants are not staked, two weedings are needed before the leaf canopy smothers most weeds. Mulching can be used as a method of weed control and to retain soil moisture. The first pruning is 4 weeks after emergence to stimulate branching and increase the growth. Irrigation is necessary for high leaf or fruit production especially under sole cropping in the dry season. Watering is done once every 3 days. Organic manure or inorganic fertilizers are used in traditional systems, but for an optimal leaf yield the recommended fertilizer application is 100 kg K_2O and 50 kg P_2O_5 per ha. In southern Nigeria application of P was found to be especially important, as N and K only increased yields in combination with application of P.
Female plants are more vigorous than male ones and produce higher vegetative yields. A high proportion of female plants by removal of a part of the male plants is desirable for high leaf and fruit yields.

Diseases and pests White leaf spot disease, caused by *Phoma sorghina*, reduces the leaf lamina. It also affects the seed. It is controlled by biweekly foliar spraying with Dithane M-45 at a concentration of 500 ppm. *Fusarium moniliforme* forms a dry powdery mass of mycelia on the fruits. *Erwinia aroideae* causes soft rot of the leaves with yellowish ooze; it also affects the fruits. A prevalent virus disease is Telfairia mosaic virus (Telfairia mosaic potyvirus) (TeMV), causing mottling of the leaves and low leaf yield; it also causes chlorosis, stunting and abnormal fruit development. It is transmit-

ted by the aphid *Aphis spiraecola* and via the seed. Fluted pumpkin is remarkably resistant to root-knot nematodes (*Meloidogyne* spp.).

Rhizopus stolonifer, *Aspergillus niger*, *Botryodiplodia theobromae* and *Erwinia* spp. are diseases of fluted pumpkin fruits in storage. Fungi may cause up to 95% loss, bacteria only 5% loss in long-term fruit storage.

A common pest of fluted pumpkins is the grasshopper *Zonocerus variegatus* which feeds on the foliage and stems. The leaf beetle *Copa occidentalis* feeds on the leaves, flowers and other plant parts, while *Spodoptera* caterpillars feed on leaves and bore into fruits. *Pachnola* (flower beetles) and *Nezara* spp. (green shield bug) feed on leaves, stem and fruits. *Margaronia indica* defoliates the plant, white beetle (*Baris* spp.) feeds on fruits. *Sylepta derogata*, *Aphis gossypii* and *Aphis spiraecola* hinder growth by feeding on stem, foliage and flower buds, and transmit viruses. There are some unidentified predators that feed on the aphids. Thrips of the genus *Taeniothrips* cause flower abortion.

Harvesting Leaf harvesting begins one month after emergence and is continued at 3–4-week intervals. The best method of harvesting is by pruning, i.e. by cutting beneath the lowest acceptable leaf. The harvest interval has no effect on the longevity of the crop and, depending on the irrigation facilities, 4–6 harvests or more are expected. In commercial production during the dry season, harvesting time in Nigeria is between November and July with 18 or more harvests. Fruits are harvested 9 weeks after fruit set.

Yield The fresh shoot yield can be as low as 500–1000 kg/ha, but it can also reach 3–10 t/ha. In home gardens in Benin, one plant occupying 3 m of fence produced 2 kg young leaves per m in the rainy season and 500 g in the dry season without irrigation. The seed yield can reach 1.9 t/ha, derived from 3000 fruits.

Handling after harvest After harvest, the succulent leaves remain fresh for just one day. In Nigeria harvested leaves are packed as 'heads' and tied in a jute bag. These are collected from the farm gate. It is possible to store the leaves for 3 days in a jute bag in an airy place but they lose turgidity. Fresh shoots are sold wholesale to traders, mainly women, who retail them in smaller bundles. Large bundles are wrapped with plantain leaves or loosely covered with old jute or kenaf cloth sacks, and sparingly watered to preserve freshness. In this way they can withstand transport to the market, where they are split into smaller units for sale.

Fruits may be stored in open shade for 1–2 months at the most. Most often they are transported by rail from the eastern part of Nigeria to the middle zone of the country. Before the fruits are sold, they are graded according to size (small, medium and large). In the market they are placed in heaps and sold as heaps or singly. Seeds are left in the fruits until they are used for planting or consumption.

Genetic resources Collection and preservation of the different accessions of West and Central Africa is necessary. Their agronomic potential and leaf and seed quality should be evaluated. In Nigeria there is currently a small collection of fluted pumpkin at the Federal University of Agriculture at Makurdi and at the National Horticultural Research Institute (NIHORT) at Ibadan. A problem is the recalcitrant character of the seed, making long-term conservation difficult. The National Agricultural Institute of Benin, the Faculty of Sciences and Technology of the University of Benin and IPGRI have recently set up a joint project to study egusi crops, including their genetic diversity. *Telfairia occidentalis* is included.

Breeding Some selections have been made in Nigeria and Cameroon, but no serious breeding work has been carried out so far.

Prospects Fluted pumpkin could become a productive leaf and seed vegetable once planting material of good cultivars is readily available. The variation in the plants from different accessions should be used to improve both the quality and quantity of seed and leaves. In Nigeria, the Department of Crop Production of the Federal University of Agriculture in Makurdi and NIHORT at Ibadan have started research work.

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Authors N.I. Odiaka & R.R. Schippers

TETRAGONIA TETRAGONIOIDES (Pall.) Kuntze

Protologue Revis. gen. pl. 1: 264 (1891).

Family Aizoaceae

Chromosome number $2n = 32$

Synonyms *Demidovia tetragonioides* Pall. (1781), *Tetragonia expansa* Murray (1783).

Vernacular names New Zealand spinach, warrigal cabbage (En). Tétragone cornue, épinard de Nouvelle-Zélande, épinard d'été (Fr). Espinafre de Nova Zelândia (Po).

Origin and geographic distribution New Zealand spinach was already a popular vegetable in New Zealand, Australia and the Pacific Islands in the 18th century. It occurs naturally in coastal areas in this region and also in Japan, China and Taiwan. Perhaps it is native to New Zealand, and has naturalized from cultivation elsewhere. Since Captain Cook's voyages it is known as an antiscorbutic plant. It was introduced in Europe and America in the late 18th century where it is a fairly common summer vegetable in home gardens, grown as a substitute for ordinary spinach (*Spinacia oleracea* L.). Yet it is seldom grown commercially, the reason being that the culinary quality is less appreciated than spinach and that it cannot compete with the latter in yield and ease of cultivation, the recalcitrant seed being the main handicap. In many subtropical regions and highland areas in the tropics it is locally grown in home gardens and sometimes for market production. In Africa it has been recorded from Senegal, and from eastern Africa from Somalia to South Africa and Madagascar, but it probably occurs in many other countries.

Tetragonia tetragonioides – planted

Uses New Zealand spinach is eaten cooked as a green leafy vegetable. It can be used in many dishes, like amaranth, spinach or other leafy vegetables with a neutral soft taste. Yet it has a distinctive slightly bitter taste. In the United States the tender tips are also eaten raw in salads.

Production and international trade New Zealand spinach has never become an important commercial vegetable due to its labour-intensive harvest and the difficult seed germination. It is grown mainly as a small-scale home garden vegetable, and production data are not available. In many countries in South-East Asia it is occasionally grown as a market vegetable, but in Africa it is rarely found at the market.

Properties The composition of New Zealand spinach per 100 g edible portion (product as purchased less 20% waste) is: water 94 g, energy 59 kJ (14 kcal), protein 1.5 g, fat 0.2 g, carbohydrate 2.5 g, Ca 58 mg, P 28 mg, Fe 0.8 mg, vitamin A 4400 IU, thiamin 0.04 mg, riboflavin 0.13 mg, niacin 0.50 mg, folate 15 µg, ascorbic acid 30 mg (USDA, 2002). The nutritional value is comparable to other medium green leafy vegetables. Most Ca is present as oxalates and not available to the human body. Consumption as a raw vegetable has been discouraged because of a high saponin content.

Whole *Tetragonia tetragonioides* plants showed distinct anti-ulcerogenic activity in tests with mice. The active principles were determined as sterylglucosides and cerebrosides.

Adulterations and substitutes In cooking New Zealand spinach may be replaced by other green leafy vegetables with a mild neutral taste, such as Ceylon spinach, amaranth, spinach and Swiss chard.

Description Fleshy annual herb, rather dark green but covered all over with minute,

Tetragonia tetragonioides – 1, plant habit; 2, flowering and fruiting shoot; 3, flower; 4, fruit. Redrawn and adapted by Achmad Satiri Nurhaman

shining, white papillae, strongly branched, with trailing-ascending stems up to 1 m long, erect when young, terete or slightly angular. Leaves succulent, arranged spirally, simple, without stipules; petiole 0.5–2.5 cm long; blade ovate-rhomboid-triangular, 1.5–11 cm × 1–7.5 cm, entire, dark green above, pale green beneath, dull on both sides. Flowers axillary, solitary or 2–3 together, bisexual, yellowish-green, inconspicuous; perianth-tube turbinate, 1.5–2 mm long during anthesis, with (3–)4(–5) unequal segments 2–3 mm long, under each segment with a short hornlet, enlarging after anthesis; stamens 4–22, filaments yellow; ovary semi-inferior, (2–)5–8(–10)-celled, styles as many as cells. Fruit a conical, obconical or globular drupe 2.5–12.5 mm long, dry and indehiscent, 4–10-seeded, surrounded by the perianth tube, with (3–)4(–5) horns. Seeds subreniform.

Other botanical information In Africa, New Zealand spinach does not occur in the wild, although it has escaped from cultivation here and there. No cultivars have been described. The seed (in fact whole fruits containing several true seeds) is traded under the species name without cultivar names. Small morphological differences in leaf shape between accessions from different origin can be observed.

Growth and development Usually the dry, hard fruits are sown. They germinate erratically, taking from 2 weeks to more than 3 months, or they stay dormant. A fruit sometimes results in one but mostly in more than one plantlet. The plant flowers and fruits readily and continuously, with no apparent negative effects on growth. New Zealand spinach is predominantly self-pollinated, but cross-pollination may occur. The fruits fall on the ground on ripening, thus reseeding itself. After germination, initial plant growth is slow with the development of an erect stem, but after 2–3 weeks growth accelerates and lateral branches are formed. Harvesting the young tips stimulates branching; the leaves on the lateral branches are smaller than the first leaves. Flowering starts after about 6 weeks, but the growth of side branches continues. After approximately 4 months plants start showing senescence and some months later they will die. However, with good care it is possible for the crop to persist for over one year, becoming a short-lived perennial.

Ecology New Zealand spinach is a xerophyte, capable of enduring long periods of drought. The succulent leaves do not wilt rapidly. In the tropics New Zealand spinach is more suitable for highland regions, at elevations above 1000 m, but with good care it can also be grown in the lowlands. It likes moderately high temperatures of 15–30°C and does not tolerate freezing. New Zealand spinach is not sensitive to day length. A fertile, sandy, well-drained soil gives the best results. It is salt tolerant, but the leaves will be of poor quality.

Propagation and planting New Zealand spinach is grown from fruits, which are easily obtained, even under tropical conditions. The fruits are very hard coated and can be kept for years without loss of viability. The weight of 1000 fruits is 65–100 g. For planting one ha, 5–15 kg of fruits are used. Before sowing they should preferably be soaked in water for a day to soften the coat and help faster germination. The fruits are covered with 1–4 cm soil. Seedlings are usually raised in nurseries and transplanted when they have 6–7 leaves into permanent beds at distances of 30–50 cm in the row

and 100 cm between the rows. Soaked fruits can also be sown directly in the field. Propagation by stem cuttings is not practised. Because initial growth is slow, a young New Zealand spinach crop can be planted in alternating rows with another quick-maturing vegetable.

Management Manure and/or fertilizer should be amply supplied to obtain rapid, tender growth. A nitrogen fertilizer is advantageous as a side dressing to stimulate regrowth after harvesting. A produce of 30 t/ha of harvested shoots contains approximately 60 kg N, 15 kg P_2O_5 and 105 kg K_2O; the total recommended fertilizer application per ha is 100 kg N, 25 kg P_2O_5 and 150 kg K_2O. Once fully developed, one plant easily covers 1 m^2 of ground surface. Mulching is not needed. Once fully established, the crop competes well with weeds, making weeding unnecessary. Although drought resistant, it is necessary to irrigate under dry conditions, giving at least 6 mm per day for a good yield of tender tops. When growth and yield become unsatisfactory, the mat of old plants may be pulled up, and the young plants which are developing underneath from fallen fruits may be used for a new crop.

Diseases and pests New Zealand spinach is little affected by diseases and pests. Rot of the prostrate stems may occur, but this is insignificant on sandy soils. Old plants may degenerate due to virus infestation. Leaf hoppers, snails and aphids are sometimes a bit troublesome. No serious soilborne diseases are known, except root-knot nematodes. These are controlled by crop rotation, e.g. with amaranth or with maize. Liberal gifts of organic fertilizer also reduce the nematode population.

Harvesting When the central stem and the branches have grown to a height and length of over 30 cm, 6–8 weeks after germination, tops of 15–20 cm may be cut or handpicked for the first harvest. As the plant spreads over the soil, harvesting of new shoots by handpicking may continue at weekly intervals over a period of several months. When regularly cut back, the plant may persist in the tropics as a short-lived perennial. This is common in home gardens, whereas market gardeners remove the crop after some months when the yield and quality have become inferior. Regular harvesting with short intervals, e.g. once per week or per 2 weeks, is recommended to promote growth of new shoots. Older leaves including stems with fruits must be avoided for consumption as they become bitter and fibrous.

Yield The yield of the first harvest amounts up to 1 kg per m^2. With continuous harvesting over a period of 3–4 months, a total yield of about 3 kg/m^2 may be obtained.

Handling after harvest The leaves do not store for more than a day at ambient temperatures. They should be consumed soon after harvest or put in a cool room.

Genetic resources No germplasm collections have been recorded.

Breeding Genetic improvement of the crop has not been undertaken. Many seed companies in Western countries sell fruits ('seed') of New Zealand spinach. Various accessions show a slight variation mainly in leaf shape.

Prospects New Zealand spinach is easy to grow, high yielding and nutritious. It is an ideal vegetable for home gardens. A few plants are sufficient for a regular supply. It is drought resistant, salt tolerant, and hardly affected by pests and diseases. It deserves more attention, especially in the African highland areas. Research could concentrate on genetic variation with possibilities for breeding, and on seed technology to solve the germination problem.

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Other references Gilbert, M.G., 1993b; USDA, 2002a.

Sources of illustration Herklots, G.A.C., 1972; Siemonsma, J.S., 1993.

Authors G.J.H. Grubben

Based on PROSEA 8: Vegetables.

THUNBERGIA LANCIFOLIA T.Anderson

Protologue Journ. Linn. Soc. Bot. 7: 19 (1863).

Family Acanthaceae

Origin and geographic distribution *Thunbergia lancifolia* occurs in DR Congo, Burundi, Tanzania, Malawi, Zambia, Angola, Zimbabwe and Mozambique.

Uses In Malawi and Zimbabwe the young leaves of *Thunbergia lancifolia* are collected from the wild, cooked and used as a vegetable, although they are rather tough. Sometimes the leaves are cooked in the sour liquid ('matsukwa') that remains after soaking maize, sometimes mixed with young leaves of sweet potato. This latter product is not much liked

and only cooked occasionally. The flowers are rich in nectar and sucked for their sweetness. In Mozambique the rhizome is applied as dried powder on swellings, and an extraction in water is drunk against bilharzia. Ash of the burned rhizome is eaten with food by women as contraceptive. In DR Congo macerated leaves are applied to burns. In Zimbabwe an infusion of the plant is used to treat skin diseases and after soaking the leaves for some hours, the extract liquid is used as hair shampoo.

Properties No data on nutritive value or chemical composition are available for *Thunbergia lancifolia*. In *Thunbergia alata* Sims, of which the leaves are also eaten but which is more important as an ornamental, phenolic compounds (caffeoylmalic acid, feruloylmalic acid and p-coumaroylmalic acid) have been found in the leaves, and in several other species iridoid glycosides (e.g. stilbericoside).

Botany Erect, branched, perennial herb or shrub up to 90 cm tall, glabrous, with woody rhizome; stems grooved. Leaves decussately opposite, simple, subsessile; blade linear-lanceolate to elliptical, oblanceolate or obovate, 4–19 cm × 1–4 cm, base attenuate, sometimes auriculate, apex acute, margin entire, glabrous or glabrescent, glossy at both surfaces. Flowers solitary, axillary, zygomorphic, large, subtended by 2 ovate bracts 3 cm × 2 cm; pedicel up to 3 cm long in flower, 6.5 cm in fruit; calyx persistent, connate at base, with unequal, short, irregular teeth; corolla tubular, 5-lobed, tube c. 3 cm × 1.5 cm, lobes unequal, c. 2 cm long, lavender to reddish, with yellow-orange throat; stamens 4, didynamous, included in tube, anthers with a spur above, hairy below, the ventral pair with a straight spur below; ovary superior, 2-celled, style cylindrical, stigma funnel-shaped, triangular. Fruit a finely pubescent capsule, subglobose at base and 1.5 cm in diameter, with a prominent beak 1.5 cm long, splitting in 2 halves at maturity.

Thunbergia is a large, poorly known genus, comprising about 100 species, and confined to the Old World tropics and subtropics. In Malawi the leaves of *Thunbergia oblongifolia* Oliv. (an erect woody herb, also known from Tanzania) are similarly used as a vegetable. *Thunbergia aurea* N.E.Br., occurring in Botswana, Namibia and South Africa, also has edible leaves. Several *Thunbergia* species are popular ornamentals, e.g. *Thunbergia alata* Sims ('black-eyed Susan') in eastern and southern Africa, and *Thunbergia grandiflora* (Roxb.) Roxb. ('blue trumpet vine'), introduced and naturalized, for example, in Nigeria. Both latter species have edible leaves.

Ecology *Thunbergia lancifolia* occurs in dry, regularly burned savanna and open woodland, at 1000–1800 m altitude.

Genetic resources and breeding *Thunbergia lancifolia* is rather widespread and not in danger of genetic erosion.

Prospects *Thunbergia lancifolia* will remain a minor vegetable, most probably only locally eaten in times of food scarcity. The large, showy, blue flowers with orange-yellow throat and the erect, short, shrubby habit make it a potential ornamental.

Major references Burkill, H.M., 1985; Burkill, I.H. & Clarke, C.B., 1899–1900; Jansen, P.C.M. & Mendes, O., 1983; Tredgold, M.H., 1986; Williamson, J., 1955.

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Authors P.C.M. Jansen

TRIANTHEMA PORTULACASTRUM L.

Protologue Sp. pl. 1: 223 (1753).

Family Aizoaceae

Chromosome number $2n = 26, 36$

Synonyms *Trianthema monogyna* L. (1767).

Vernacular names Horse purslane, carpetweed, giant pigweed (En). Pourpier courant (Fr).

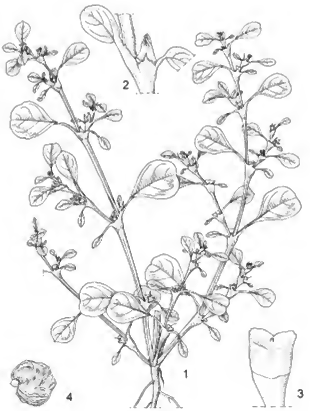
Origin and geographic distribution *Trianthema portulacastrum* is distributed pantropically, including in tropical Africa, where it is widespread.

Uses In Africa the young tops and leaves of *Trianthema portulacastrum* are eaten as a cooked vegetable or in soups; there are records of such use from Ghana, Cameroon and Tanzania. In India and South-East Asia it is similarly used. However, the plant may cause diarrhoea or paralysis, particularly when older leaves are eaten. When used as a fodder, it can produce similar effects and most domestic animals refuse to eat it. The seeds are harmful contaminants in food grains and other crop seeds. The plant has a potential value as a source of organic matter. The roots have cathartic and stomachic properties and in Africa, the Philippines, Thailand and India they are used to relieve obstructions of the liver and to

relieve asthma. In Asia they are given as an emmenagogue, and in large doses as an abortifacient. The leaves are diuretic and are applied in the treatment of oedema, jaundice, painful discharge of urine and dropsy. A decoction of the herb is used as a vermifuge and is useful in rheumatism; it is considered an antidote to alcoholic poisoning. The fleshy nature of the leaves makes them suitable for use as a wound-dressing or poultice. In Nigeria the old leaves are used in a treatment against gonorrhoea. In Gabon a decoction of the powdered root is taken to treat venereal discharge. Dried plants are occasionally traded in local markets and by herbalists.

Properties *Trianthema portulacastrum* contains the alkaloid trianthemine and the steroid ecdysterone. The flavonoid C-methylflavone has been isolated from the dichloromethane extract of the herb. The seeds contain 12.5% of a fatty oil, and the leaves contain carotene and oxalates. Pharmacological investigations of extracts of *Trianthema portulacastrum* revealed effects on the liver. An ethanol extract of the aerial parts showed a significant reduction of CCl_4-induced chronic hepatocellular damage of Swiss albino mice. A chloroform extract showed a significant reduction of diethylnitrosoamine-induced hepatocarcinogenesis in Sprague-Dawley rats. In particular the incidence, numerical preponderance, multiplicity and size distribution of visible preneoplastic nodules were reduced. An ethanol extract of the plant has also shown some effects on blood pressure of guinea pigs and on their ileum. Ecdysterone is a potential chemosterilant, and possesses moulting hormone activity, giving a full pupation-response for larvae of the housefly. *Trianthema portulacastrum* shows allelopathic effects on other weeds and crops including sorghum, pumpkin, eggplant, radish, several pulses and wheat, by inhibiting seed germination and vigour of seedlings. Interestingly, it is also autotoxic as plant extracts reduce its seed germination, shoot length and vigour.

Botany An annual, prostrate or ascending, succulent herb up to 60 cm tall, often much branched, glabrous or finely pubescent, with a firm taproot. Leaves opposite, simple, those of the same pair very unequal in size; stipules small; petiole 0.5–3 cm long, dilated and sheathing at the base, pairwise connate into a funnel-shaped sheath; blade ovate-obovate to obcordate-oblong, 1–5 cm × 0.5–4.5 cm, entire, purple or green. Flowers solitary, axillary, the



Trianthema portulacastrum – 1, plant habit; 2, node with flower; 3, fruit, floral tube removed; 4, seed.
Source: PROSEA

lower part hidden by the sheath, bisexual, regular, pale pink, rarely white; perianth 5-lobed, 4–5 mm long, tube fused with the petiolar sheath, with the 2 pointed bracteoles, and with the stem, lobes obtuse with a long dorsal but almost apical mucro; stamens 10–25, filaments white, glabrous; ovary superior, turbinate, truncate, 1-celled, style c. 1.5 mm long, unilaterally stigmatose throughout its length. Fruit a circumscissile capsule 5 mm × 3 mm, partly exserted from the persistent perianth, 2–8-seeded. Seeds reniform, 1.5–2.5 mm long, with faint wavy ribs, black. Seedling with epigeal germination.

Trianthema comprises about 17 species and is closely related to *Sesuvium* and *Cypselea*. These 3 genera are thought to link the *Aizoaceae* to the *Portulacaceae*.

The production of flowers and seeds of *Trianthema portulacastrum* starts 20–30 days after germination of the seeds.

Ecology *Trianthema portulacastrum* is a common weed in fields and in open, sunny localities such as roadsides; it is often found on clayey soils near the sea, up to 200 m altitude.

Management Seeds of *Trianthema portulacastrum* germinate between 20°C and 45°C, with an optimum at 35°C. More than 50% of fresh seeds germinate within 4–8 days of incubation. When stored under field conditions, germination increases during 7–8 months. Optimum sowing depth is 1 cm.

Trianthema portulacastrum is often an aggressive weed. It can be controlled either by uprooting the plants before flowering, or by spraying e.g. the mycoherbicide *Gibbago trianthemae* or the herbicide Fernoxone. It is a host for aubergine mosaic virus, tobacco mosaic virus, rice tungro bacilliform virus, rice tungro spherical virus, cucumber mosaic virus and watermelon mosaic virus. It is attacked by trianthema mosaic virus, which causes distinct necrotic lesions on the leaves; this virus may also attack several other weeds and tobacco. It is also attacked by fungi such as *Macrophomina phaseolina*, causing dry root rot, and by *Colletotrichum capsici*, *Fusarium semitectum*, *Drechslera* spp. and *Stemphylium* spp., all of which cause leaf spot diseases.

Genetic resources and breeding *Trianthema portulacastrum* is extremely widespread and occurs in anthropogenic habitats, which means that there is no risk of genetic erosion. Much effort is made to eradicate it as a noxious weed, but it seems well able to survive since it is resistant to many herbicides.

Prospects The nutritive aspects (and possible toxicity) of *Trianthema portulacastrum* need more investigation before its value as a vegetable can be determined. The anti-hepatotoxic effects of its extracts in cases of jaundice and alcohol poisoning are interesting. These effects merit further research, as do those of the isolated ecdysterone as a chemosterilant in pest control.

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Sources of illustration Aguilar, N.O., 2001c.

Authors P.C.M. Jansen

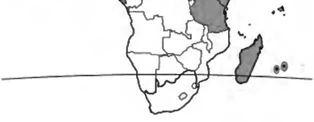
TRICHOSANTHES CUCUMERINA L.

Protologue Sp. pl. 2: 1008 (1753).
Family Cucurbitaceae
Chromosome number $2n = 22$
Synonyms *Trichosanthes anguina* L. (1753).

Vernacular names Snake gourd, snake tomato (En). Patole, concombre-serpent, serpent végétal (Fr). Abóbora serpente, quiabo de metro (Po).

Origin and geographic distribution The genus *Trichosanthes* is native to southern and eastern Asia, Australia and islands of the western Pacific. *Trichosanthes cucumerina* is found wild throughout these areas. It was probably domesticated in ancient times in India, from where non-bitter and large-fruited types may have migrated to other tropical areas. It is grown as a minor vegetable in many countries of tropical Asia. It is locally grown as a vegetable in home gardens in Africa, where it has been recorded from several countries and probably occurs in many more. Commercial growers around big cities in East Africa occasionally grow cultivars of snake gourd imported from India for people of Indian origin.

Uses Immature fruits, and more rarely young shoots and leaves of snake gourd are used as cooked vegetables. In some types all plant parts have an unpleasant odour that disappears upon cooking. Young fruits may be somewhat bitter but this also disappears during cooking. The bitterness of the fruits increases with maturity. The fully mature fruit contains a soft, red, tomato-like pulp that is used in stews or sauces as a substitute for tomato puree or paste. However, people prefer true tomato because of the astringent acidic



Trichosanthes cucumerina – planted

taste of snake gourd pulp. The use of snake gourd as a replacement for tomato is reported from Sierra Leone, Liberia, Côte d'Ivoire, Ghana, Benin and Nigeria.

The mature fruit has been reported as purgative. An infusion of the young shoot is mildly aperient, the leaf sap is emetic and the seeds are anthelmintic and antiperiodic. The plants are also grown in compounds as a dual purpose vegetable and ornamental for the white, fringed flowers, fragrant at night, and the decorative fruits.

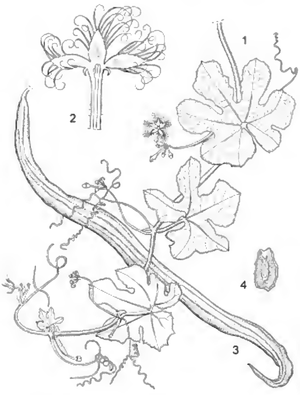
Production and international trade In West Africa young fruits and pulp of mature fruits are sometimes traded on local markets, but in most places snake gourd is only produced for own consumption. Mauritius produces about 700 t snake gourd fruit per year and exports 2–3 t. No other data on production and trade in Africa are known. In India, snake gourd is a rather important market vegetable, especially in the south. The cultivation of the plant for fruit pulp production is increasing and is spreading widely along the coast of West Africa.

Properties The nutritive value of immature fruits of snake gourd per 100 g edible portion (94%) is: water 92.9 g, energy 89 kJ (21 kcal), protein 0.5 g, fat 0.3 g, carbohydrate 4.1 g, fibre 1.7 g, Ca 26 mg, P 20 mg, Fe 0.3 mg, thiamin 0.04 mg, riboflavin 0.06 mg, niacin 0.3 mg, folate 15 μg, ascorbic acid trace (Holland, B., Unwin, I.D. & Buss, D.H., 1991). No data are available on the composition of the red fruit pulp and the leaves.

A galactose-specific lectin with agglutination activity is present in the seeds. The seeds also contain a ribosome-inactivating protein (trichoanguin). The chloroform extract of *Trichosanthes cucumerina* roots showed significant antibacterial activity against *Pseudomonas aeruginosa*, and seed extracts showed nematicidal activity.

Adulterations and substitutes The young fruits can be replaced by other cucurbits such as squash (*Cucurbita pepo* L.), bottle gourd (*Lagenaria siceraria* (Molina) Standl.) or ridged gourd (*Luffa acutangula* (L.) Roxb.).

Description Monoecious annual herb, climbing by 2–3-branched tendrils; stem slender, 5-angled. Leaves alternate, simple; stipules absent; petiole 2–10 cm long, furrowed, succulent, scabrid hairy; blade slightly to deeply 5–7-lobed, 7–25 cm × 8–20 cm, cordate at base, margin dentate, pubescent. Flowers unisexual, regular, 5-merous, white; calyx tubular; corolla lobes fringed with hairlike outgrowths; male flowers in 5–many-flowered axillary racemes on 10–30 cm long peduncles, with 3 stamens; female flowers solitary and sessile, with inferior, 1-celled ovary, long-hairy, stigmas 3. Fruit a very slender, long and cylindrical berry, often twisted, 30–180 cm × 2–10 cm, greenish-white when immature, dark red when mature, many-seeded. Seeds flattened, 1–1.5 cm long, greyish-brown, sculptured, margin undulate. Seedling with epigeal germination.



Trichosanthes cucumerina – 1, flowering shoot; 2, top of female flower in longitudinal section; 3, fruit; 4, seed.
Source: PROSEA

Other botanical information The genus *Trichosanthes* comprises about 100 species, of which a few have been domesticated in Asia, snake gourd being the most important. Two varieties are distinguished within *Trichosanthes cucumerina*: the wild var. *cucumerina* occurring from India, Sri Lanka and China, through South-East Asia, to northern Australia, and the cultivated var. *anguina* (L.) Haines with its elongated fruits. Only traditional landraces of *Trichosanthes cucumerina* are used in West and Central Africa, whereas improved cultivars from India are grown in East Africa.

Growth and development Flowering starts 5–6 weeks after emergence of the seed-

ling. Male flowers appear first followed by female ones 3 days later. The flowers open in the evening or in the early morning. Anthers dehisce several hours before anthesis, stigmas are receptive from a few hours before anthesis to a few hours after. Pollination is effected by insects, including bees, wasps, ants, butterflies and moths. The fruits can be harvested 2–3 months after sowing or planting and the harvest may continue for 2 months.

Ecology Wild snake gourd grows in scrub vegetation, along forest edges and in open forest, from sea-level to 1500 m altitude. Snake gourd is well adapted to the humid tropical lowlands. The optimum average day temperature for growth is 30–35°C with a minimum of 20°C. It does not tolerate dry soil and requires a good moisture reserve in the soil. However, it is sensitive to waterlogging.

Propagation and planting Seeds of snake gourd are dried after removal from the mature fruits. They are recalcitrant. The seeds are sown in planting holes or on ridges 100–150 cm apart and 60–75 cm between plants, requiring 4–6 kg seed per ha. Alternative to this direct sowing method, seeds can be raised in the nursery and seedlings transplanted to the field when they have 2 true leaves. However, farmers prefer direct sowing because of the delicate character of the plant.

Management In peri-urban market gardening, snake gourd is trained along poles or trellises, and in home gardens the plants are allowed to trail over a wall or fence. When the fruits start developing, a stone or other weight is attached to the apex of each fruit in order to produce straight fruits. Snake gourd responds well to manuring and fertilizer application, but caution should be taken not to apply too much nitrogenous fertilizer as this leads to excessive stem production at the expense of fruit production. In areas where seasonal moisture stress is experienced, there is a need for irrigation.

Diseases and pests Downy mildew (*Pseudoperonospora cubensis*) and anthracnose (*Colletotrichum lagenarium*) attack immature and mature fruits. They are controlled by removal of the attacked fruits and by spraying of fungicide, e.g maneb. Snake gourd is susceptible to damage by root-knot nematodes. It is attacked by several insects, including *Bactrocera* and *Dacus* fruit flies, *Diaphania* caterpillars, *Lasioptera* gall midges and *Bemisia* white flies, but information on the extent of damage and measures of control are lacking especially for Africa.

Harvesting Fruits are picked when still immature about 2 weeks after fruit set, when they are 30–60 cm in length, or up to 1 m depending on the cultivar, and may weigh up to 1 kg. When fruit pulp production is the objective of cultivation, the harvest of the fruits takes place at full maturity. The same ripe fruits may be used for seed extraction.

Yield Landraces produce 6–10 fruits per plant, improved cultivars up to 50. The total yield of young fruits ranges from 8–10 t/ha. If ripe fruits of about 1 kg are harvested, a yield of up to 30 t/ha is reported.

Handling after harvest The young fruits store well for 10–14 days at a temperature of about 15°C and high humidity.

Genetic resources Germplasm collections are available at genebanks at NACGRAB, Ibadan, Nigeria, at Kerala Agricultural University, Thrissur, India, at NPGRL-IPB, Los Baños, Philippines, and at Cornell University, New York, United States.

Breeding Breeding work has been performed by Indian seed companies, selecting for high yield, good fruit quality and disease resistance. Efforts are needed to breed for increasing the female to male flower ratio. There is also need to breed for fruit pulp with less astringent acidic taste.

Prospects *Trichosanthes cucumerina* is a newly introduced crop of increasing importance in several parts of Africa, including Ghana and Nigeria, mainly for the red fruit pulp as a substitute for tomato sauce. There are no indications that the consumption of young snake gourd fruits will become of great importance in Africa.

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Sources of illustration Gildemacher, B.H., Jansen, G.J. & Chayamarit, K., 1993.

Authors M.O. Soladoye & A.A. Adebisi

TRIPLOCHITON ZAMBESIACUS Milne-Redh.

Protologue Bull. Misc. Inform. Kew: 271 (1935).

Family Sterculiaceae (APG: Malvaceae)

Vernacular names Wine-cup, Zambesi wine-cup tree (En).

Origin and geographic distribution *Triplochiton zambesiacus* is endemic to the Zambesi valley and the lower reaches of its tributaries.

Uses Cooked leaves are eaten in Zambia and Zimbabwe. The wood is hard and has been used for yokes for oxen. The fine shade caused by the dense foliage and the handsome flowers make it a desirable ornamental.

Properties No data on chemical composition of *Triplochiton zambesiacus* are available, but data on the composition of leaves of the related *Triplochiton scleroxylon* K.Schum. are available from Côte d'Ivoire. Fresh leaves had a moisture content of 74.7%, and they contained per 100 g dry matter: energy 668 kJ (160 kcal), protein 29.2 g, fat 2.2 g, starch 3.0 g, sugar 2.3 g, fibre 51.0 g, Ca 1114 mg, Mg 551 mg, Fe 9.2 mg, β-carotene 16.5 mg, riboflavin 0.78 mg and ascorbic acid 165 mg (Herzog, F., Farah, Z. & Amado, R., 1993). The mucilage content of the leaves per 100 g was 4.2 g as compared to 9.1 g in the fruits of *Abelmoschus esculentus* (L.) Moench.

Botany Medium-sized tree up to 18 m tall, with a straight trunk, frequently multi-stemmed; bark smooth, flaking, pale grey; crown rounded with dense foliage; branchlets slender, glabrous. Leaves alternate, simple; stipules c. 7 mm long, caducous; petiole 5–7 cm long; blade palmately 5–9-lobed, up to 12 cm × 14 cm, base cordate, apex of the lobes shortly acuminate. Inflorescence a 1–4-flowered, axillary or terminal cyme. Flowers bisexual, regular, 5-merous; calyx bell-shaped, c. 2 cm long; petals c. 3.5 cm × 2.5 cm, white or yellow, deep red towards the base; androgynophore 9 mm long, c. 3 mm in diameter; style 2 mm long. Fruit consisting of 5 tomentose, 1-seeded carpels with a pubescent wing of 7 cm × 3 cm.

Triplochiton comprises only 2 species. *Triplochiton scleroxylon* is an important timber tree with a West and Central African distribution; the leaves of this species are eaten as well.

Flowering of *Triplochiton zambesiacus* takes place in the rainy season, from December till April, and flowers are open in the morning only. Fruits are persistent and may remain on the tree into the next flowering season. The seeds are dispersed by wind.

Ecology *Triplochiton zambesiacus* occurs along river banks and on alluvial floodplains. It is often associated with termitaria.

Management Propagation can be done by seed. When seed availability is a problem multiplication by stem cuttings, as is practised for *Triplochiton scleroxylon*, would be feasible.

Genetic resources and breeding The limited distribution and the specific habitat of *Triplochiton zambesiacus* make it vulnerable, although there are no indications of immediate threats of extinction or genetic erosion.

Prospects Research on nutritive value and phytochemistry is desirable to evaluate the use of *Triplochiton zambesiacus* as a vegetable. The possibility to extend the use of *Triplochiton zambesiacus* as an ornamental to other tropical and subtropical areas is obvious. If transfer of genes to *Triplochiton scleroxylon* proves to be possible, there might be interesting opportunities for breeding of this timber tree.

Major references Coates Palgrave, K., 1983; Milne-Redhead, E., 1936; Pardy, A.A., 1956; Wild, H., 1961b.

Other references Herzog, F., Farah, Z. & Amado, R., 1993; Huxley, A. (Editor), 1992c; Nketiah, T., Newton, A.C. & Leakey, R.B.B., 1998.

Authors C.H. Bosch

TRIUMFETTA ANNUA L.

Protologue Mant. pl. 1: 73 (1767).

Family Tiliaceae (APG: Malvaceae)

Chromosome number $2n = 20$

Vernacular names Burweed (En). Herbe à panier (Fr). Kibosa (Po).

Origin and geographic distribution *Triumfetta annua* occurs from Nigeria east to Ethiopia and Eritrea, and south to South Africa, also in Madagascar, as well as southern and eastern Asia. It is locally cultivated.

Uses In East and southern Africa, e.g. Uganda and Malawi, *Triumfetta annua* is eaten as a leafy vegetable, cooked as a mucilaginous spinach-like relish. It is mainly collected from the wild and rarely cultivated. In Nigeria and Cameroon the bark of the young green stem, called 'slimy stick', is used to extract a mucilaginous exudate for the preparation of a slimy soup called 'nkwi', highly appreciated especially by the Bamalike tribe of Cameroon. The slimy substance is mainly used as baby food and for young children not yet able to eat coarse starchy foods. Because of its high energy value, 'nkwi' soup is often the first dish

Triumfetta annua – wild

given to women who have delivered a child. It is also used as an appetizer. The fibrous bark is used as string, as is the case for other *Triumfetta* species.

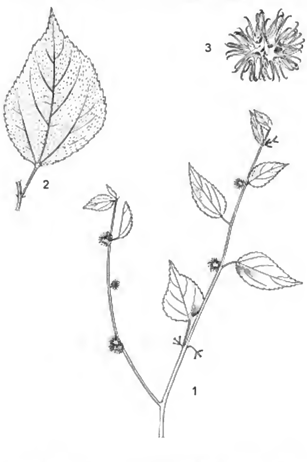
Production and international trade The demand for the leaves and young stems at markets is limited. Most people who prepare 'nkwi' soup grow some plants at home and trade in the prepared soup is much more lucrative than trade in the young stems. No data are available on production or yield, and international trade is either non-existent or very limited.

Properties The nutritional composition of burweed (*Triumfetta* sp.) leaves per 100 g edible portion is: water 78.4 g, energy 285 kJ (68 kcal), protein 4.2 g, fat 0.4 g, carbohydrate 15.2 g, fibre 3.4 g, Ca 392 mg, P 76 mg, Fe 29.2 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). There are no records on the composition of the exudate.

Adulterations and substitutes Not only *Triumfetta annua* is used for the preparation of 'nkwi' soup, but also related species such as *Triumfetta cordifolia* Guill., Perr. & A.Rich., *Triumfetta pentandra* Guill., Perr. & A.Rich. and *Triumfetta rhomboidea* Jacq., but the latter 3 species are more important for their fibre. The leaves of these species are also used as a cooked vegetable comparable to *Triumfetta annua*.

Description Annual or short-lived perennial, erect herb up to 1(–2) m tall; stem 1.5–2.5(–4) mm in diameter, yellowish, initially with 1–2 longitudinal lines of crispy hairs, later glossy, occasionally prickly at base. Leaves alternate, simple; stipules linear, up to 4.5 mm long; petiole (1–)2–3.5(–4.5) cm long; blade ovate to elliptical, rarely slightly 3-lobed, (1.5–)3–9.5(–11.5) cm × (1–)2–6 cm, base slightly cordate to obtuse, apex acute to acuminate, margin serrate-crenate, glabrous to scabrid. Inflorescence a cyme, 3–7 together in uppermost leaf axils, often opposite the leaf, each cyme 3-flowered. Flowers bisexual, regular, 5-merous, yellow to orange; pedicel c. 1.5 mm long; sepals oblanceolate, up to 5.5(–7) mm × 1.5 mm, with apical spine; petals broadly spatulate, c. 3 mm × 2 mm, clawed; stamens 4–8; ovary superior, spherical. Fruit a spherical to ellipsoid capsule 1–2 cm in diameter including hooked spines up to 7 mm long, brown or black, glabrous or inconspicuously hairy, dehiscent with 4 valves, few-seeded. Seeds reniform, c. 2 mm long, brown or black.

Other botanical information *Triumfetta* is a pantropical genus of about 100 species. *Triumfetta annua* is often confused with *Triumfetta pentandra* and *Triumfetta rhomboidea*, but is characterized by its glabrous or inconspicuously hairy fruits, leaves with simple hairs and lacking glands, and stems having 1–2 lines of hairs. In *Triumfetta annua* 2 forms



Triumfetta annua – 1, flowering and fruiting branch; 2, leaf; 3, fruit.
Redrawn and adapted by Iskak Syamsudin

are recognized: forma *annua* and forma *piligera* Sprague & Hutch., the first having glabrous fruits, the second inconspicuously hairy fruits with long, simple hairs.

Growth and development As soon as the rains start, new shoots develop and these grow very fast. Such shoots can be very brittle and are easily damaged. New shoots continue to develop, allowing farmers to harvest throughout the rainy season.

Ecology *Triumfetta annua* occurs in bushland, woodland, forest edges and as a weed in fields, usually in more or less shaded locations, up to 2150 m altitude.

Propagation and planting When *Triumfetta annua* or other *Triumfetta* species are cultivated for the young stems, cuttings of 15–20 cm long are taken from the top end of the harvested stems. Since the crop does not perform well under direct sunlight, the cuttings are usually planted in the shade of a tree. They are planted in a circle with a spacing of 10–15 cm. If the cutting is not planted straight upward, adventitious roots may develop, causing a reduced capacity to produce slime. Therefore, some farmers tie the cuttings to a taller plant, e.g. plantain, to ensure that they grow upright.

Management The management of *Triumfetta* plants cultivated for 'slimy sticks' is restricted to weeding, provision of support and some irrigation during periods of drought.

Harvesting Young burweed leaves are picked when required. Stems are cut just above ground level when they are 75–100 cm long. They are prepared by removing all leaves and the terminal part where the stem has a diameter of less than 1 cm. The resulting sticks are either taken to the homestead or tied into bundles and brought to the market.

Handling after harvest Burweed leaves have to be cooked well to soften them and to develop their sliminess. Potash is sometimes added to facilitate this. To prepare 'nkwi' soup the bark is separated from the stem by placing it over a fire for a short while until it loosens; the peeled bark is then placed in hot water for about 15 minutes and squeezed by hand to extract the sap. The sap and the water form a mucilaginous substance to which salt, pepper, various spices and a range of other ingredients are added. Care must be taken not to include vegetable oil, since this will spoil the product.

Genetic resources It is unlikely that genetic erosion of *Triumfetta annua* is occurring as it has a very wide distribution. No germplasm collections are currently held at genebanks or research institutes.

Prospects The cultivation of *Triumfetta annua* as a vegetable is restricted to a few areas only. For these areas, research is needed on chemical composition of the bark exudate, genetic variation, cultivars and cultural practices.

Major references Berhaut, J., 1967; Jacobs, T.V., 1997a; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Mbinglo, S. & Ntangti, 1998; Schippers, R.R., 2002a; Stevels, J.M.C., 1990; Whitehouse, C., Cheek, M., Andrews, S. & Verdcourt, B., 2001; Williamson, J., 1955.

Other references Jacobs, T.V., 1997b; Jacobs, T.V., 1998; Jacobs, T.V., 1999.

Sources of illustration Lakshminarasimhan, P. & Sharma, B.D., 1991; Whitehouse, C., Cheek, M., Andrews, S. & Verdcourt, B., 2001; Wild, H., 1984.

Authors R.R. Schippers

TULBAGHIA ALLIACEA L.f.

Protologue Suppl. pl.: 193 (1782).

Family Alliaceae

Chromosome number $2n = 12, 24, 36$

Vernacular names Wild garlic, woodland garlic (En).

Origin and geographic distribution *Tulbaghia alliacea* occurs in Malawi, Botswana, Zimbabwe and Mozambique; also in South Africa, Swaziland and Lesotho.

Uses In Zimbabwe and South Africa the leaves of *Tulbaghia alliacea* are cooked as a relish, alone or with leaves of other plants, such as *Adenia* species. The rhizome is scraped clean and boiled with meat in stews or roasted as a vegetable. Young leaves are chopped and used to flavour soups, stews, pickles and omelettes as a substitute for shallot.

In South Africa the bruised rhizome is used in baths for the relief of fever, rheumatism or paralysis. Small doses are used as a laxative.

Properties *Tulbaghia alliacea* contains alliaceous compounds; the whole plant smells strongly of onions.

Botany Perennial herb with a swollen rhizome up to 10 cm long; roots thick, fleshy. Leaves 6–8 in a rosette, with very short sheath at base, linear, 15–20(–25) cm × 3–5 mm, fleshy, glaucous. Inflorescence a (3–)6–10(–13)-flowered umbel on a scape 15–30 cm long; bracts 1–2 cm long. Flowers bisexual, regular; pedicel up to 2 cm long; perianth tube cylindrical-campanulate, 6 mm × 2–4 mm, glaucous

green, lobes in 2 whorls of 3, lorate-lanceolate, 2–4 mm × 1.5–2 mm, olive green with white margins; corona annular, cup-shaped, 2–3 mm long, fleshy, obscurely 3- or 6-crenate, greenish brown fading to orange-brown; stamens in 2 whorls of 3, inserted on the corona, without filaments; ovary superior, ovoid, 3-celled, style short, stigma capitate. Fruit an obcordate capsule up to 8 mm long. Seeds triangular, flat, black.

Tulbaghia comprises 22 species and is confined to southern Africa, north to Tanzania and Angola. In Malawi the flowers and leaves of *Tulbaghia cameronii* Baker are cooked and eaten as a side-dish, mixed with other ingredients. In Zimbabwe *Tulbaghia leucantha* Baker, known as 'vlei garlic', is used as a vegetable relish in the same way as *Tulbaghia alliacea*.

Ecology *Tulbaghia alliacea* grows in a variety of habitats from lowland swamps to moist sandy meadows and barren ground, up to 2000 m altitude. It is often a garden weed.

Management Although *Tulbaghia alliacea* is not cultivated for use as a vegetable or ornamental, it is occasionally grown as a pot-plant by plant amateurs. The plants have a dormancy period during winter, when they must be kept relatively dry. The rhizomes are planted in a loam-based compost (free draining but moisture retentive).

Propagation can be done by dividing the rhizome after the dormancy period, before active growth has started. Multiplication by seeds is possible, but *Tulbaghia* species are reported to hybridize readily, so care must be taken to avoid cross-pollination. Seeds sown at temperatures of 18–21°C normally germinate within 14 days. The following year clumps of young plants are potted off and flowering can be expected within a year or two from the date of sowing.

Genetic resources and breeding *Tulbaghia alliacea* does not seem to be endangered by genetic erosion because it is quite common and its use seems restricted. An extensive collection of living *Tulbaghia* plants is maintained at Marwood Hill Gardens, North Devon, United Kingdom.

Prospects The importance of *Tulbaghia alliacea* and other *Tulbaghia* species as a relish seems restricted to local use and there are no signs it has special qualities that onion and garlic would lack. Prospects as a vegetable specialty therefore seem to be restricted.

Major references Benham, S., 1993; Tredgold, M.H., 1986; van Wyk, B.E. & Gericke, N., 2000; Watt, J.M. & Breyer-Brandwijk, M.G., 1962.

Other references Burbidge, R.B., 1978; Vosa, C.G., 1975; Vosa, C.G., 1983; Williamson, J., 1955.

Authors W.J. van der Burg

URERA CORDIFOLIA Engl.

Protologue Bot. Jahrb. 33: 121 (1902).

Family Urticaceae

Origin and geographic distribution *Urera cordifolia* occurs in Nigeria, Cameroon, Central African Republic and Gabon. It is part of a complex of closely related species, including *Urera flamigniana* Lambinon, *Urera gravenreuthii* Engl. and *Urera mannii* (Wedd.) Benth. & Hook.f. ex Rendle, having different distribution areas in West and Central Africa.

Uses The leaves of *Urera cordifolia* and related species are eaten in soups and as a mucilaginous cooked vegetable. The bark fibre is strong and used for ropes and fishing lines. There are numerous local medicinal uses reported of leaf sap, leaf decoctions and dried, powdered leaves, e.g. to treat dysentery, neuralgia, deafness and other ear affections, diarrhoea with blood, chest pain, male impotency and furuncles, as an aphrodisiac and laxative, and as a component of arrow poison. The whole plant is used as a diuretic. The sap of crushed inflorescences is taken as a poison antidote. The small red fruits are used as a bait in bird traps.

Properties Aqueous leaf extracts of the Neotropical *Urera baccifera* (L.) Wedd. have demonstrated anti-inflammatory and analgesic activities, but nothing is known about the phytochemistry of the African *Urera* species.

Botany Dioecious liana up to 10 m long; stem c. 3 cm in diameter, attached by adventitious roots, 5-lobed in cross-section, older branches with 5 rows of prickle-like protuberances, young branches with stinging hairs, these also on leaves and inflorescences. Leaves alternate, simple; stipules connate, bifid, early caducous; petiole up to 12(–36) cm long; blade orbicular to ovate, up to 18(–45) cm long, base rounded to slightly cordate, apex acuminate, margin crenate to dentate, 3-veined from the base. Inflorescence an axillary, lax panicle; male inflorescence up to 16 cm long; female inflorescence up to 6 cm long. Flowers unisexual, regular, small; male flowers with c. 2 mm long pedicel, reddish; female flowers sessile, c.

1 mm long. Fruit an achene up to 2 mm long, surrounded by the perianth.

Urera comprises about 35 species and occurs in tropical Africa including Madagascar, tropical America and Hawaii. The taxonomy of the West African *Urera* species is incompletely known. The fact that leaf morphology has usually been the basis for separating species seems to be the underlying problem.

Ecology Like other *Urera* species, *Urera cordifolia* occurs in dense, humid, lowland forest.

Genetic resources and breeding Utilization by man does not seem to pose a serious threat to *Urera cordifolia* and related species, which are threatened more by destruction of lowland forest.

Prospects The use of *Urera cordifolia* as a vegetable is likely to remain restricted. Despite the numerous medicinal local uses, there is no indication of interest from phytochemists or pharmacologists. A taxonomic revision of West African *Urera* species is long overdue.

Major references Burkill, H.M., 2000; Keay, R.W.J., 1958c; Letouzey, R., 1968.

Other references Busson, F., 1965; Kerharo, J. & Bouquet, A., 1950.

Authors C.H. Bosch

URERA OBOVATA Benth.

Protologue Hook., Niger Fl.: 516 (1849).

Family Urticaceae

Vernacular names Scratchbush (En).

Origin and geographic distribution *Urera obovata* occurs from Sierra Leone to southern Nigeria.

Uses The leaves of *Urera obovata* are eaten in Côte d'Ivoire as a cooked vegetable and are added to soups. A leaf decoction is used to treat dysentery (Nigeria) and as an aphrodisiac (Côte d'Ivoire). The fruits are said to be edible.

Properties Fresh leaves of *Urera obovata* contain per 100 g edible portion: water 81.2 g, energy 222 kJ (53 kcal), protein 2.8 g, fat 0.6 g, carbohydrate 11.6 g, fibre 2.7 g, P 41 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968).

Aqueous leaf extracts of the Neotropical *Urera baccifera* (L.) Wedd. have demonstrated anti-inflammatory and analgesic activities, but nothing is known about the phytochemistry of the African *Urera* species.

Botany Dioecious liana up to 30 m long; stem attached by adventitious roots, with prickle-like protuberances, young branches with stinging hairs, these also on leaves and inflorescences. Leaves alternate, simple; stipules connate, early caducous; petiole up to 10 cm long; blade obovate, up to 16 cm long, base rounded or obtuse, apex abruptly acuminate, margin crenate to dentate, 3-veined from the base. Inflorescence an axillary, lax panicle; male inflorescence branched, up to 20 cm long; female inflorescence c. 7.5 cm long. Flowers unisexual, regular, small, shortly pedicellate; male flowers with 4–5 stamens; female flowers with tubular perianth with 4 short teeth. Fruit an achene up to 2.5 mm long, surrounded by the fleshy perianth.

Urera comprises about 35 species and occurs in tropical Africa including Madagascar, tropical America and Hawaii. The taxonomy of the West African *Urera* species is incompletely known. *Urera obovata* is closely related to *Urera oblongifolia* Benth., or possibly conspecific with it. A major distinction between them is that in the former the leaf margin is distinctly crenate or toothed and in the latter entire or minutely serrate. Both can be distinguished from other *Urera* species by the shape of the female perianth, which is tubular with 4 short teeth, whereas in other species it is 3–4-lobed with rather unequal lobes. The leaves of *Urera oblongifolia* are mucilaginous and eaten in Sierra Leone mixed with cassava leaves.

Ecology *Urera obovata* occurs in lowland forest, often in humid localities.

Genetic resources and breeding There are no indications that *Urera obovata* or *Urera oblongifolia* are threatened with genetic erosion.

Prospects *Urera obovata* will remain a locally used vegetable. The medicinal properties deserve research. A taxonomic revision of West African *Urera* species is needed.

Major references Burkill, H.M., 2000; Busson, F., 1965; Leung, W.-T.W., Busson, F. & Jardin, C., 1968.

Other references Keay, R.W.J., 1958c.

Authors C.H. Bosch

URERA TRINERVIS (Hochst.) Friis & Immelman

Protologue Nord. Journ. Bot. 7: 126 (1987).

Family Urticaceae

Synonyms *Elatostema trinervis* Hochst. (1844), *Urera cameroonensis* Wedd. (1869).

Origin and geographic distribution *Urera trinervis* is widely distributed in the lowland

forest regions of tropical Africa, from Ghana east to south-western Ethiopia, and south to South Africa (Natal).

Uses *Urera trinervis* is occasionally used in DR Congo as a cooked vegetable. The bark fibre is used for making ropes and is esteemed in both DR Congo and Nigeria for making fishing lines. In Cameroon the leaves are used to treat scabies. In Tanzania the Shambaa people chew the leaves and swallow the juice to treat bilious disorders. In Nigeria the leaf-sap is drunk to treat intestinal disorders. The stems yield potable water when cut; in Congo this water is drunk to treat tachycardia.

Properties Aqueous leaf extracts of the tropical American *Urera baccifera* (L.) Wedd. have demonstrated anti-inflammatory and analgesic activities, but nothing is known about the phytochemistry of the African *Urera* species.

Botany Dioecious liana up to 60 m long; stem up to 7 cm in diameter, terete, attached by adventitious roots; stinging hairs usually only on inflorescences. Leaves alternate, simple; stipules connate, bifid at apex, early caducous; petiole up to 6 cm long; blade elliptical, ovate or obovate, up to 12 cm long, base cuneate, truncate or rounded, apex long-acuminate, margin entire, 3-veined from the base. Inflorescence an axillary, lax panicle; male inflorescence c. 6.5 cm long; female inflorescence c. 2 cm long. Flowers unisexual, regular, small, c. 1.5 mm long, 4-merous; male flowers with c. 1 mm long pedicel; female flowers sessile, with indistinctly lobed perianth. Fruit an achene up to 2 mm long, surrounded by the fleshy perianth.
Urera comprises about 35 species and occurs in tropical Africa including Madagascar, tropical America and Hawaii.

Ecology *Urera trinervis* occurs in rainforest, riverine forest and coastal forest, especially at forest edges and in clearings, sometimes epiphytic. In tropical Africa it occurs up to 1600 m altitude.

Management In DR Congo *Urera trinervis* is sometimes cultivated for its bark fibre, but no information on cultivation practices appears to have been published.

Genetic resources and breeding *Urera trinervis* is widespread and not in danger of genetic erosion.

Prospects *Urera trinervis* is likely to remain of local importance only as a vegetable and fibre crop.

Major references Burkill, H.M., 2000; Friis, I., 1986; Friis, I., Immelman, K. & Wilmot-Dear, C.M., 1987; Kokwaro, J.O., 1993.

Other references Badilla, B., Mora, G., Lapa, A.J., Silva, E. & Jose, A., 1999; Friis, I., 1989a; Hauman, L., 1948; Letouzey, R., 1968.

Authors C.H. Bosch

URTICA MASSAICA Mildbr.

Protologue Notizbl. Bot. Gart. Berlin-Dahlem 8: 275 (1923).

Family Urticaceae

Vernacular names Maasai stinging nettle, forest nettle (En). Ortie massaïe (Fr). Mpupu (Sw).

Origin and geographic distribution *Urtica massaica* occurs in eastern DR Congo, Rwanda, Burundi, Kenya, Uganda and northern Tanzania.

Uses The leaves of *Urtica massaica* are wilted, boiled and eaten, or used young and uncooked, as is the case with several other *Urtica* species throughout the world. In Tanzania this vegetable is considered a famine food, but in Uganda it is locally more popular and frequently eaten.
The Maasai use the leaves to cure stomach-ache. In the Kisii area of Kenya the leaves are used to treat malaria. In Tanzania the macerated roots and leaves are used for the treatment of hepatic diseases. In Rwanda and Burundi *Urtica massaica* is used alone and in mixtures with other plant species to treat numerous ailments: bruises, injuries, fractures, venereal diseases, rheumatism and urethral leak. In Uganda the leaves are used as a repellent against rats and for protection of crops from grazing cattle.

Properties No extracts of *Urtica massaica* that have been tested have shown any in-vitro activity against *Plasmodium falciparum*. A crude extract of *Urtica massaica* has been tested against soil pathogens (*Fusarium oxysporum*, *Alternaria passiflorae* and *Aspergillus niger*) but did not show biological activity against any of these pathogens. The sting of *Urtica massaica* is painful but wears off after a few minutes. Acetylcholine, histamine and 5-hydroxytryptamine have been implicated in itching from the stinging hairs of other *Urtica* species.

Botany Dioecious, erect, perennial herb up to 2 m tall, little branched; rhizome creeping; all parts with 1.5–2 mm long stinging hairs. Leaves opposite, simple; stipules fused, inter-

petiolar, 1–2 cm long; petiole up to 4.5 cm long; blade ovate, 7–13 cm × 6–10.5 cm, base cordate, apex acute to shortly acuminate, margin usually double-serrate. Inflorescence an axillary, lax, cymose panicle up to 4.5 cm long, 4 at each node. Flowers unisexual, regular, 4-merous, c. 1 mm long, with free tepals in 2 unequal pairs; male flowers with 4 stamens and rudimentary ovary; female flowers sessile, with superior, ovoid, 1-celled ovary. Fruit an ovoid, flattened achene c. 1 mm long.

Urtica comprises about 80 species and is almost cosmopolitan, with most species in temperate regions of the northern hemisphere and about 5 in Africa, 2 of which are introduced weeds. *Urtica simensis* Hochst. ex A.Rich., an Ethiopian endemic, is also used as a vegetable; it can be distinguished by smaller stipules and simply serrate leaf margins, and it is less robust. *Urtica dioica* L. has been reported from tropical Africa (DR Congo, Ethiopia), probably as an introduced weed in gardens, but its presence is not confirmed by herbarium specimens. In South Africa and many other regions of the world its leaves are used as a vegetable. It is widely used medicinally in treating asthma, allergies, coughs, rheumatism, symptoms of benign prostatic hyperplasia and paralyzed limbs, and has been recommended as a diuretic and antispasmodic and to stimulate hair growth.

Ecology *Urtica massaica* occurs in clearings and natural open glades in rainforest and moist evergreen bushland, often near human dwellings. It is found mainly at altitudes of 1500–3250 m and is often associated with buffaloes. In grazing areas it is considered an important weed. In Uganda it is an important component of the vegetation of abandoned fields and in forest clearings where grazing takes place.

Management To stimulate growth of tender sprouts the old stems are cut back. Harvesting should be done with hands protected because of the stinging hairs.

Genetic resources and breeding *Urtica massaica* is common in its area of distribution and not threatened with genetic erosion. A single germplasm accession is held by the National Genebank of Kenya.

Prospects As a vegetable *Urtica massaica* will remain important only locally. The widespread interest in other *Urtica* species because of their medicinal properties, combined with the many uses of *Urtica massaica* in traditional medicine, may eventually attract attention from phytochemical research.

Major references Friis, I., 1989b; Katende, A.B., Ssegawa, P. & Birnie, A., 1999; Maundu, P.M., Ngugi, G.W. & Kabuye, C.H.S., 1999; Ruffo, C.K., Birnie, A. & Tengnäs, B., 2002.

Other references Kokwaro, J.O., 1993; Maitai, C.K., Talalaj, S., Njoroge, D. & Wamugunda, R., 1990; Marshall, F., 2001; Muregi, F.W., Chhabra, S.C., Njagi, E.N.M., Lang'at Thoruwa, C.C., Njue, W.M., Orago, A.S.S. Omar, S.A. & Ndiege, I.O., 2003; Ngigi, A.N. & Ndalut, K., 2000.

Authors C.H. Bosch & R.R. Schippers

URTICA SIMENSIS Hochst. ex A.Rich.

Protologue Tent. fl. abyss. 2: 260 (1850).

Family Urticaceae

Origin and geographic distribution *Urtica simensis* is endemic to Ethiopia.

Uses The leaves and young shoots are edible, eaten mainly in times of famine.

Properties The boiled leaves give a burning sensation in the mouth if not crushed before boiling. Acetylcholine, histamine and 5-hydroxytryptamine have been implicated in itching from the stinging hairs of other *Urtica* species.

Botany Dioecious, erect, perennial herb up to 1 m tall, almost unbranched; rhizome creeping; petioles, leaf blades and inflorescences with c. 2.5 mm long stinging hairs. Leaves opposite, simple; stipules fused, interpetiolar, 0.5–1 cm long; petiole c. 4 cm long; blade ovate, 5–12 cm × 3–8 cm, base rounded to slightly cordate, apex broadly acute or acuminate, margin simply serrate. Inflorescence an axillary, lax, cymose panicle up to 5 cm long, 4 at each node. Flowers unisexual, regular, 4-merous, c. 1.5 mm long, with free tepals in 2 unequal pairs; male flowers with 4 inflexed stamens and rudimentary ovary; female flowers with superior, ovoid, 1-celled ovary. Fruit an achene c. 2 mm long.

Urtica comprises about 80 species and is almost cosmopolitan, with most species in temperate regions of the northern hemisphere and about 5 in Africa, 2 of which are introduced weeds. *Urtica massaica* Mildbr. is also used as a vegetable in East Africa; it can be distinguished by larger stipules and usually double-serrate leaf margins, and it is more robust. *Urtica dioica* L. has been reported from tropical Africa (DR Congo, Ethiopia), probably as an introduced weed in gardens, but its presence is

not confirmed by herbarium specimens. In South Africa and many other regions of the world its leaves are used as a vegetable.

Ecology *Urtica simensis* is found in grassland and is common in disturbed localities, often plentiful near houses. It is found at 1500–3500 m altitude. It is considered a weed in fields and pastures.

Management The plants grow throughout the year and can be harvested whenever there is a need. For collection the hands should be covered to protect against the stinging hairs. The leaves are cut and spread between two hides on the ground and crushed by stamping or rubbing. After boiling for about 3 hours, the leaves are crushed once more to obtain a smooth puree.

Genetic resources and breeding *Urtica simensis* is common in its area of distribution and therefore not threatened with genetic erosion.

Prospects As a vegetable *Urtica simensis* will remain important only locally. The widespread interest in other *Urtica* species because of their medicinal properties might eventually attract attention from phytochemical research for *Urtica simensis*.

Major references Friis, I., 1989a; Lemordant, D., 1971b; UN-EUE, 2001d.

Other references Friis, I., 1989b; Westphal, E., 1975; Zemede Asfaw & Mesfin Tadesse, 2001.

Authors C.H. Bosch

VALERIANELLA LOCUSTA (L.) Laterr.

Protologue Fl. bordel., ed. 2: 93 (1821).

Family Valerianaceae

Chromosome number $2n = 16$

Synonyms *Valerianella olitoria* (L.) Pollich (1826).

Vernacular names Cornsalad, lamb's lettuce, European cornsalad (En). Mâche, doucette (Fr). Alface de cordeiro, alface de coelho, alface da terra (Po).

Origin and geographic distribution *Valerianella locusta* is a native of Europe, temperate western Asia and northern Africa. It is widely cultivated, and has become naturalized in parts of the United States. It is occasionally cultivated in DR Congo, East Africa and Madagascar.

Uses The most common use of *Valerianella locusta* is of whole young plants in salads. Alternatively plants are cooked or blanched. The stems of young inflorescences are edible as well.

Properties Leaves contain per 100 g: water 93.1 g, energy 92 kJ (22 kcal), protein 2.0 g, fat 0.4 g, carbohydrate 3.4 g, fibre 0.8 g, Ca 35 mg, Mg 13 mg, P 49 mg, Fe 1.7 mg, thiamin 0.07 mg, riboflavin 0.08 mg, niacin 0.4 mg and ascorbic acid 35 mg (Rubatzky & Yamaguchi, 1997).

Botany Erect, dichotomously branched annual herb up to 40 cm tall. Leaves opposite, simple, up to 7.5 cm long; blade of lower leaves broadly spatulate to ovate, apex obtuse, margin entire to sinuate. Inflorescence a dense, head-like cyme. Flowers bisexual, small; calyx reduced to minute teeth; corolla with slightly unequal lobes, white or pale blue; stamens 3; ovary inferior, 3-celled. Fruit an achene up to 2.5 mm long.

Valerianella comprises about 50 species. *Valerianella microcarpa* Lois. is considered the only native species of sub-Saharan Africa and occurs in alpine vegetation in Kenya. *Valerianella eriocarpa* Desv., Italian cornsalad, which is closely related to *Valerianella locusta*, has a largely similar distribution and is occasionally cultivated in Europe and the United States.

Ecology *Valerianella locusta* is a weed of arable land in its area of origin. It prefers a fairly rich, light soil although it tolerates a wide range of soils and humidity. It is frost-resistant and reasonably adapted to subtropical climates, and in the tropics it can be cultivated only at higher altitudes.

Management Propagation is done by direct seeding in fine soil at a depth of 1 cm in rows 15 cm apart. About 1 g of seed is needed per m^2. For home consumption, sowing should be done successively to ensure a continuous supply. Whole plants are harvested when they have 8–12 leaves. Alternatively ratooning is practised by cutting at 5 cm above ground level. Shading, sufficient moisture and nitrogen fertilizer will help to delay flowering. Overgrown plants will go to seed and re-seeding will take place.

Genetic resources and breeding Many cultivars of cornsalad have been released in Europe and the United States. They fall roughly in 2 groups of, on the one hand hardy, rosette-forming plants and on the other hand productive, long-leaved cultivars that are more sensitive.

Prospects In highland tropical Africa *Valerianella locusta* may continue to be grown for home consumption or for the local market. It is likely to remain a vegetable crop of limited importance.

Major references Rubatzky, V.E. & Yamaguchi, M., 1997; van den Bergh, M.H., 1993; Wiersema, J.H. & Léon, B., 1999.

Other references Huxley, A. (Editor), 1992c; Walters, S.M., 1976.

Authors C.H. Bosch

VERNONIA AMYGDALINA Delile

Protologue Cent. pl. Afr. Voy. Méroé: 41 (1826).

Family Asteraceae (Compositae)

Chromosome number $2n = 40$

Synonyms *Gymnanthemum amygdalinum* (Delile) Walp. (1843).

Vernacular names Bitterleaf, common bitterleaf (En). Vernonie, vernonie commune, ndole (Fr). Sucumadeira, pau fede (Po).

Origin and geographic distribution *Vernonia amygdalina* occurs wild in most countries of tropical Africa, from Guinea east to Somalia and south to north-eastern South Africa, and in Yemen. It is commonly grown as a vegetable in Benin, Nigeria, Cameroon, Gabon and DR Congo, and to a lesser extent in their neighbouring countries. The Luhya people in western Kenya use *Vernonia amygdalina* as a vegetable, but do not cultivate it.

Uses Bitterleaf is a highly appreciated vegetable in West and Central Africa and can be consumed in various dishes. In Nigeria, where the Yoruba name for this crop is 'ewuro' and the Igbo call it 'onugbu', leaves are boiled in soups. Leaves are sometimes sold in the market after being shredded, parboiled and made into fist-sized balls. In Cameroon the processed leaves are cooked with meat and/or prawns mixed with ground peanuts to make a famous dish called 'ndole'. Alternatively, whole leaves are cooked together with cassava or yam tubers, whereas the leaves are also dried and ground to powder for use in soups. In Cameroon the leaves are sometimes eaten unprocessed and raw mixed with palm oil and salt. The leaves are browsed by goats. Dry stems and branches provide fuel. Young twigs are used as toothpicks or chewing sticks. The plant is sometimes grown as a hedge. The branches are used as stakes to line fields.

Vernonia amygdalina – wild and planted

Vernonia amygdalina is commonly used in traditional medicine. Leaf decoctions are used to treat fever, malaria, diarrhoea, dysentery, hepatitis and cough, as a laxative and as a fertility inducer. They are also used as a medicine for scabies, headache and stomach-ache. Root extracts are also used as treatment against malaria and gastrointestinal disorders. In Nigeria leaves are placed on a wound as a substitute for iodine. One of the most common medicinal uses of *Vernonia amygdalina* is as a treatment against intestinal worms including nematodes. Not only humans but also chimpanzees ingest the bitter pith of *Vernonia amygdalina* for the control of intestinal nematode infections. In Zimbabwe a root infusion is used to treat sexually transmitted diseases. Bark infusions are also taken to treat fever and diarrhoea, dried flowers against stomach disorders. *Vernonia amygdalina* is also useful as a control agent against diseases in plants. The ash from burnt branches is used to control seed-borne fungi (*Curvularia*, *Aspergillus*, *Fusarium* and *Penicillium* spp.) thus ameliorating seed viability and germination capacity. It has also been used for brewing beer as a substitute for hop. *Vernonia amygdalina* is a well-known bee plant.

Production and international trade The leaves are sometimes collected from the wild, but most people prefer leaves from selected and cultivated plants which are generally less bitter. Bitterleaf is usually grown for home consumption and less often for sale at the market, but there is an increasing tendency to sell the processed product rather than branches with leaves. In Cameroon processed leaves sell for up to five times the price of the raw commodity. Processed leaves are exported from West Africa in dried or deep frozen form and offered in major markets of African vegetables in Europe. No production statistics are available.

Properties The nutritional composition of *Vernonia amygdalina* leaves per 100 g edible

portion is: water 82.6 g, energy 218 kJ (52 kcal), protein 5.2 g, fat 0.4 g, carbohydrate 10.0 g, fibre 1.5 g, Ca 145 mg, P 67 mg, Fe 5.0 mg, ascorbic acid 51 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968). This composition is in line with other dark green leaf vegetables.

The bitterness is caused by sesquiterpene lactones (e.g. vernodalin, vernolepin and vernomygdin) and steroid glucosides (vernoniosides). Some of these compounds have significant antiparasitic activity, especially vernodalin and vernonioside B1. Vernolepin showed platelet anti-aggregating properties. Vernodalin and vernomygdin have cytotoxic activity.

Aqueous extracts of *Vernonia amygdalina* leaves exhibit cytostatic action to retard the growth of human breast cancer cells. In tests with rats a sesquiterpene extract from the leaves showed antihepatotoxic activity. Extracts of leaves and root bark showed antimalarial activity against *Plasmodium berghei* in vivo in mice and against *Plasmodium falciparum* in vitro. Extracts also showed potent antileishmanial activity. Chewing sticks made from *Vernonia amygdalina* wood exhibited activities against bacteria that are significant in periodontal disease. Leaves showed activities against various bacteria and viruses.

Adulterations and substitutes Leaves of *Vernonia hymenolepis* A.Rich. and some other *Vernonia* species are used for the same purposes as *Vernonia amygdalina*. Processed bitterleaf is an expensive product and for this reason unscrupulous dealers sometimes add other plant material to increase the volume.

Description Shrub or small tree up to 10 m tall, much branched; trunk up to 40 cm in diameter; bark grey to brown, smooth, becoming fissured; young branches densely pubescent. Leaves alternate, simple; stipules absent; petiole 0.2–4 cm long; blade ovate-elliptical to lanceolate, 4–15(–28) cm × 1–4(–15) cm, cuneate or rounded at base, shortly acuminate at apex, margin minutely toothed to coarsely serrate, finely pubescent but often glabrescent, pinnately veined. Inflorescence a head, arranged in terminal, compound, umbel-like cymes; stalk of head up to 1 cm long, pubescent; involucre cylindrical to broadly ellipsoid, 3–5 mm long, bracts 3–7-seriate, 1–4.5 mm long, appressed. Flowers bisexual, regular, 5-merous, strongly exserted from the involucre; pappus consisting of outer linear, caducous scales up to 1.5 mm long and of inner creamy or brownish bristles 4–7 mm long; corolla tubular, 5–8 mm long, whitish, glandular, with

Vernonia amygdalina – *1, leaf; 2, flowering branch; 3, flowering head; 4, fruit.*
Redrawn and adapted by Iskak Syamsudin

erect lobes; stamens with anthers united into a tube, with appendages at apex; ovary inferior, 1-celled, pubescent and glandular, style hairy, 2-branched. Fruit a 10-ribbed achene 1.5–3.5 mm long, pubescent and glandular, brown to black, crowned by the much longer pappus bristles. Seedling with epigeal germination.

Other botanical information *Vernonia* is the largest genus of the tribe *Vernonieae* with close to 1000 species; it occurs mainly in South America and Africa. More than 300 species have been described from Africa with about one third occurring in Madagascar. Apart from *Vernonia amygdalina* several species are eaten as vegetable, of which *Vernonia hymenolepis* is most important. *Vernonia colorata* (Willd.) W.F.M.Drake is closely related to *Vernonia amygdalina*. It differs in its more or less entire leaves and glabrous fruits. Leaves of *Vernonia colorata* are mainly collected from the wild, and its primary use is as a medicinal plant. Other species occasionally cultivated as a vegetable but more often collected from the wild are *Vernonia cinerea* (L.) Less. in Kenya, *Vernonia poskeana* Vatke & Hildebrandt in Zimbabwe, which are both also more important as medici-

nal plants, *Vernonia appendiculata* Less. in Madagascar and *Vernonia perrottetii* Walp. in Sierra Leone.

Growth and development *Vernonia amygdalina* can grow into a tree, but in cultivation it is mostly pruned to a shrub or hedge. Once established in a garden, leaves or young shoots can be picked for up to 7 years, but for commercial production farmers prefer younger plants. Plants flower in the dry season (January and early February in West and Central Africa). Regular harvesting of the shoots stimulates new growth thus retarding flower initiation. Harvesting of only leaves hampers regrowth. Towards the dry season new leaves become smaller and become dark greyish green in colour; these are very coarse and bitter, especially those close to the inflorescence.

Ecology *Vernonia amygdalina* occurs naturally along rivers and lakes, in forest margins, woodland and grassland, up to 2000 m altitude. It often occurs in disturbed localities such as abandoned farmland, and can be found growing spontaneously in secondary forest. It requires full sunlight in cultivation. Flowering is induced by short days. It prefers a humid environment although it is fairly drought tolerant. It can be found on all soil types, but performs best in humus-rich soils.

Propagation and planting Propagation is possible by seed, but most farmers use stem cuttings. Cuttings used for propagation from mature stems are selected on the basis of attributes such as degree of bitterness, leaf size and growth characteristics. In home gardens more than one type is often grown because young people prefer the sweeter, less bitter types and elderly people the more bitter ones. Cuttings may be planted erect or slanting at an angle of 45° to obtain more sideshoots. Cuttings grow faster than seedlings. Seed may be collected from dry flower heads. It is broadcast on nursery beds prepared of humus-rich soil and shaded from excessive heat and sunlight. Seed takes 2–3 weeks to germinate. During dry periods, it is important to water the nursery beds frequently. Some 4–6 weeks after emergence, seedlings can be transplanted. In home gardens people plant bitterleaf amongst other crops or as a hedge or live fence; in commercial fields it is planted in rows.

Management Weeding, mulching and the application of organic manure in the nursery stage contributes to healthy and rapid growth of seedlings and cuttings. A regular supply of moisture is important and irrigation is profitable during the dry season. Old branches should be pruned back to a low level to stimulate the production of larger, succulent and abundant foliage. This is best done before the arrival of the rains. When adequate water is available, it takes only about 3 weeks for fresh shoots to develop after pruning. Young plants are more productive than older ones and commercial farmers prefer to plant a new crop at the beginning of every new season or after the second year. They do not remove their old crop until they have been able to harvest the first regrowth at the start of the season because this commands a premium price.

Diseases and pests Apart from a leaf curl virus, there are no major diseases that affect production. Pests do not cause major damage either, although many pest species have been recorded on bitterleaf in northern Nigeria. They include thrips, aphids, ants, white fly, *Empoasa* spp., *Sphearocoris annulus*, *Fabricius* spp., *Ptyelus grossus*, *Polyclaeis* spp. and *Xanthochelus vulneratus*. As a remedy, people traditionally sprinkle wood ash on the leaves to keep ants and aphids away. The bitterleaf weevil *Lixus camerunus* may damage stems and branches by making tunnels, causing branches to break.

Harvesting During the rainy season, harvesting takes place by cutting the leafy shoots, allowing new side shoots to develop, which can be harvested a few weeks later. Stems of various lengths are cut in the afternoon and these are sorted and tied into bundles of equal length. Depending on the season, stems brought to the market have a length of 30–50 cm, often longer during the peak period. Bundles of 15–20 stems weighing 1–2 kg are often made, but smaller ones are made during periods of scarcity. The bundles are kept overnight, placed upright in a basin of water and sometimes covered with jute bags to avoid desiccation. The bundles themselves are tied together into bigger bundles before they are carried to the market. During dry periods people pick only the leaves and leave the shoots intact. Young pale green sprouts with large leaves grown under irrigation during dry periods fetch high prices in the market, because by this time most leaves of other plants are small and very bitter. Some commercial farmers do not harvest their crop during peak production times when home gardens can supply all vegetables needed and prices are low. By not cutting at this time there will be a better crop later in the season, when prices are expected to be higher.

Yield Highest yields are obtained during the rainy season, the peak being in May–August. Production statistics are not available.

Handling after harvest Leaves may be shredded and pounded in a mortar. During pounding foam develops. The foam and bitterness is removed by repeatedly rinsing the leaves with water between poundings. Salt or lime is sometimes added in the mortar to speed up the maceration. Leaves may be shredded and boiled first. Kneading the boiled leaves is sometimes sufficient, but often a pestle and mortar are used to soften them. The pounded leaves are rinsed until the water that drains off is no longer green. When the water is drained off the leaves are ready for use. They may also be sold as such, or preserved by drying (which somewhat changes the taste) or deep freezing. Alternatively, the leaves are pressed into fist-sized balls before they are marketed. A more bitter product is obtained by stopping the formation of foam during pounding by adding palm oil.

Genetic resources No germplasm collections of *Vernonia amygdalina* are known to exist. The plant grows in many African countries and under different conditions, so that there is probably ample diversity for plant breeders to select from. As commercial cultivars are not yet used, there is no threat yet of genetic erosion.

Breeding No cultivar research or any breeding activities take place at the official research centres, although farmers make and maintain their own selections.

Prospects Bitterleaf is an important vegetable in West and Central Africa, which, once established, is easy to produce and rather resistant to drought, making it popular in home gardens. The laborious and time-consuming task of processing bitterleaf has encouraged the commercialization of processed leaves. This processing is fast becoming a source of income in urban areas. *Vernonia amygdalina* has multiple medical properties that deserve further research. Research on genetic variability and agronomy is also needed.

Major references Beentje, H.J., 2000; Burkill, H.M., 1985; Dupriez, H. & De Leener, P., 1989; Kalanda, K. & Lisowski, S., 1995; Misari, S.M., 1992; Okafor, J.C., 1997; Schippers, R., 1997b; Stevels, J.M.C., 1990; van der Zon, A.P.M. & Grubben, G.J.H., 1976; van Epenhuijsen, C.W., 1974.

Other references Akachuku, C.O., 2001; Babalola, O.O., Anetor, J.I. & Adeniyi, F.A., 2001; Biholong, M., 1986; Burkill, H.M., 2000; Coates Palgrave, K., 1983; Durand, J.M., 1959; Huffman, M.A., 2003; Kokwaro, J.O., 1993; Kupchan, S.M., Hemingway, R.J., Karim, A. & Werner, D., 1969; Leung, W.-T.W., Busson, F. & Jardin, C., 1968; Mbinglo, S.B., 1998; Taiwo, O., Xu, H.X. & Lee, S.F., 1999.

Sources of illustration Stevels, J.M.C., 1990.

Authors Fidelia Ucheck Fomum

VERNONIA HYMENOLEPIS A.Rich.

Protologue Tent. fl. Abyss. 1: 378 (1848).
Family Asteraceae (Compositae)
Chromosome number $2n = 20$

Synonyms *Vernonia calvoana* (Hook.f.) Hook.f. (1868), *Vernonia leucocalyx* O.Hoffm. (1901), *Baccharoides calvoana* (Hook.f.) M.A.Isawumi (1993).

Vernacular names Sweet bitterleaf, bitterleaf (En). Vernonie douce, vernonie, ndole (Fr).

Origin and geographic distribution *Vernonia hymenolepis* occurs locally wild in mountainous and high plateau regions of West, Central, East and southern Africa. Its cultivation is only known from Nigeria and Cameroon.

Uses *Vernonia hymenolepis* is especially appreciated in Cameroon, where it is known as 'bayangi bitterleaf' or 'ndole'. The leaves are consumed fresh and in dry form as a garnish, potherb or salad. The plant is sometimes planted as a hedge around homes and gardens both for vegetable use and for the ornamental value of the large white or purple flowering heads. The plants also help to stabilize the soil, especially on slopes. *Vernonia hymenolepis* is

Vernonia hymenolepis – *wild and planted*

used medicinally as a cure for pneumonia, and a hot leaf placed on a wound is said to stop bleeding. Juice from crushed leaves is used to treat diarrhoea in babies and jaundice. In Kenya a root decoction is used as a purgative and to treat abdominal pains. Dry branches and stems serve as fuel.

Production and international trade The production of this vegetable mainly takes place on mixed cropped farms and in home gardens. In western Cameroon there are specialized farms with sweet bitterleaf as the main crop, and this type of production appears to be on the increase. During the dry season, an irrigated sweet bitterleaf crop may fetch a high price at the markets, particularly since at this time it is not as bitter as *Vernonia amygdalina* Delile. The produce is sold both at local markets and in the big cities. Deep frozen and dried leaves of *Vernonia hymenolepis*, *Vernonia amygdalina* and *Vernonia colorata* (Willd.) W.F.M.Drake are exported from Nigeria and Cameroon to the major markets of African vegetables in Europe.

Properties The nutritional composition of *Vernonia hymenolepis* leaves is comparable to that of bitterleaf (*Vernonia amygdalina*). It is less bitter than other *Vernonia* species. The sesquiterpene lactone vernolepin was isolated from *Vernonia hymenolepis* collected in Ethiopia. This compound showed antitumour activity and platelet anti-aggregating properties.

Adulterations and substitutes *Vernonia hymenolepis* used in dishes may be replaced by *Vernonia amygdalina* and other *Vernonia* species.

Description Perennial herb, shrub or small tree up to 12 m tall; young branches densely tomentose. Leaves alternate, simple, sessile; blade elliptical to lanceolate, 5.5–34 cm × 1–9.5 cm, cuneate to long-attenuate and sometimes auriculate at base, acuminate at apex, margin minutely to coarsely toothed, pubescent below, pinnately veined. Inflorescence a head, arranged in terminal, compound, umbel-like cymes; involucre ovoid to hemispherical, 1.5–4 cm long, bracts 2–6-seriate, up to 3.5 cm long, with green or white appendages, recurved or not. Flowers bisexual, regular, 5-merous, strongly exserted from the involucre; pappus consisting of many-seriate bristles, up to 1.5 cm long, pale brown; corolla tubular, 1–2 cm long, whitish to purple, glandular, with short, erect lobes; stamens with anthers united into a tube, with appendages at apex; ovary inferior, 1-celled, glabrous to pubescent, style hairy, 2-branched. Fruit a ribbed achene 3–6.5 mm long, glabrous to slightly pubescent, dark brown, crowned by the much longer, caducous pappus bristles. Seedling with epigeal germination; hypocotyl 1–3 cm long, epicotyl 2–6 mm long; cotyledons elliptical, 0.5–1.5 cm long, green.

Vernonia hymenolepis – 1, leaf; 2, flowering branch; 3, flower.
Redrawn and adapted by Iskak Syamsudin

Other botanical information *Vernonia* is the largest genus of the tribe *Vernonieae* with close to 1000 species; it occurs mainly in South America and Africa. More than 300 species have been described from Africa with about one third occurring in Madagascar.
Vernonia calvoana is considered here as a synonym of *Vernonia hymenolepis*. However, it is often considered as distinct, differing in often larger, less densely pubescent leaves, usually larger and recurving involucral bracts and more often glabrous fruits. The species show considerable overlap in these characters.

Growth and development Emergence of the seedling starts about 5 days after sowing. Early growth during the rainy season is so rapid that plants grow as tall as 40–50 cm in just 4 weeks. This rapid growth continues as

long as there is ample moisture in the soil. Flower initiation begins with the onset of the dry season or during periods of drought. The degree of soil fertility greatly influences leaf size.

Ecology *Vernonia hymenolepis* occurs along rivers and roadsides, in forest margins, old cultivation sites and bushed grassland, but also in montane forest. It is often found in disturbed habitats. Plants thrive at temperatures of less than 30°C at altitudes of (600–)1400–3000 m. The minimum rainfall required is 840 mm/year. Generally, the plants grow well in loose, moist soil rich in humus.

Propagation and planting Seeds are collected from dry flower heads by rubbing them, followed by winnowing. The 1000-seed weight is 2.4 g. Propagation usually takes place by broadcasting or by sowing in lines on raised beds. Nursery beds are shaded to prevent excessive evaporation. When the seedlings are 2–3 weeks old with 4–6 leaves, they are pruned by nipping the growing point and then transplanted with a ball of soil. At this stage, bitter seedlings are screened by tasting one of their leaves. This selection process not only secures a better quality crop, but also serves to reduce bitterness in the next generations. In sole cropping, seedlings are transplanted at a spacing of 20 cm × 30 cm or even closer; when intercropped in home gardens the spacing is about 75 cm × 75 cm. Some farmers sow directly in lines spaced at 30 cm and thin their crop to a distance of 20–25 cm at the 3–4-week stage. The thinned material can be sold to other farmers as seedlings or consumed. Propagation by cuttings is sometimes practised to multiply selected plants. Cuttings with 4 buds taken from mature plants are used; they are planted slanting. Rooting of the cuttings is not always successful and plant growth is much slower than in seedlings, so that this method is only used in home gardens when a particular plant type is appreciated.

Management Sweet bitterleaf is very sensitive to drought and should therefore be irrigated daily. Weeding is hardly required in a closely spaced monocrop. Mulching is occasionally practised. Urea is applied as a topdressing to promote regrowth of new leaves after harvest. Ratoon cropping is practised in south-western Cameroon: shoots are harvested about 10 cm above ground level, allowing new shoots to develop. Some farmers only harvest once and re-sow immediately thereafter because young plants grow faster than side shoots. In this case farmers may use a planting distance of 20 cm × 20 cm only.

Diseases and pests Main diseases of sweet bitterleaf are a potyvirus causing leaf mosaic, green vein banding and distortion of the leaves, and wilting caused by *Fusarium* sp., which may kill the plants. Pests include snails, crickets and variegated grasshopper (*Zonocerus variegatus*), which cuts off young leaves and stems. Methyl-paraffin is used for control.

Harvesting Picking of leaves starts at 4–6 weeks after sowing or 6–8 weeks after transplanting. Harvesting is done either by cutting the young shoots or gathering the leaves only. Although the harvest of leaves only is often preferred, this system may adversely affect the development of the plant. Best results are obtained during the rainy season by cutting the shoots at 5–10 cm above the soil, which will then be replaced by one or two side shoots. These side shoots could be harvested 3–4 weeks later and, depending on soil moisture and fertility, this process could be repeated two or three times. In the dry season, when new shoots develop only slowly if at all, farmers pick leaves only. With adequate irrigation, the ratoon system is possible even during the dry season.

Yield Highest yields are obtained during the rainy season. In Cameroon the period May–August is the peak harvesting period, when a bundle of 15–20 stems of 40–50 cm and occasionally as long as 90 cm could weigh about 1 kg. Stem weight, quantity and quality are greatly reduced in the dry season. The initial harvest yields about 1 kg/m^2 which decreases to about 500 g/m^2 at the third harvest. No data are available for leaf yield.

Handling after harvest The harvested produce is left in a cool place and when needed water is sprinkled to delay shrinking. Leaves are sliced, washed and squeezed. To reduce bitterness, people may rub the leaves or boil them for 5 minutes in water containing lime. Freezing or drying and packaging may follow. Dried leaves may be reduced to powder but this process changes the taste. The dry leaves must be steeped in water before consumption.

Genetic resources *Vernonia hymenolepis* is widespread and occurs often in disturbed habitats, and there is no danger of genetic erosion. Its diversity in the wild is great, but as yet hardly studied or exploited. Wild, often purple-flowered plants are very bitter.

Breeding Cross-pollination takes place through both insects and the wind. Isolation at the propagation stage is therefore important

since crosses between wild and cultivated plants often result in bitter-tasting plants.

Prospects *Vernonia hymenolepis* is a much appreciated but rather scarce vegetable. Vegetative propagation would be the best way to maintain uniformity, but poor rooting and slow regrowth remain a problem. Once new and uniform cultivars are developed and high quality seed becomes available, this species may well take over the whole market for bitterleaf including the common bitterleaf (*Vernonia amygdalina*). Processing the leaves before marketing them could become a new source of income as consumers would not need to spend so much time on the preparation of dishes, which may be important for people in cities.

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Other references Burkill, H.M., 1985; Fidelia, U.F., 2000; Isawumi, M.A., 1993; Jeffrey, C., 1988; Kupchan, S.M., Hemingway, R.J., Werner, D., Karim, A., McPhail, A.T. & Sim, G.A., 1968; Mbinglo, S.B., 1998; Numfor, F.A., 1997; Tabuna, H., 2000.

Sources of illustration Stevels, J.M.C., 1990.

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VIGNA LUTEOLA (Jacq.) Benth.

Protologue Mart., Fl. bras. 15: 194 (1859).

Family Papilionaceae (Leguminosae - Papilionoideae, Fabaceae)

Chromosome number $2n = 22$

Synonyms *Vigna fischeri* Harms (1899).

Vernacular names Hairypod cowpea, dalrymple vigna, deer pea (En).

Origin and geographic distribution *Vigna luteola* occurs throughout the tropics and is widespread in mainland Africa. It has been grown on research stations in Réunion and Mauritius.

Uses The flowers of *Vigna luteola* are eaten as a boiled vegetable in Ethiopia and Malawi. In Malawi the roots are dug up by children, peeled and chewed to extract a sweet juice. The tender cooked seeds are edible.

Because it is palatable for livestock and grows and nodulates well in wet and slightly saline soils, *Vigna luteola* has been tested as a pasture plant and cover crop in a number of countries including Ghana, Zambia, Argentina, Cuba and Australia. However, disadvantages as a pasture crop are its rather short life cycle, susceptibility to frost and to insect pests, and troublesome seed production.

In Ethiopia the leaves and flowers are mixed with *Hagenia abyssinica* (Bruce) J.F.Gmel. flowers to treat syphilis and ulcers. In Argentina the plant is used to control lipid adsorption and cholesterol levels, and it is also reported to have antimicrobial and antineoplastic properties.

Properties With a crude protein content of 17.4% of dry matter at flowering *Vigna luteola* qualifies as an excellent fodder. The flavonoids quercetin and isorhamnetin, isolated from the leaves, are thought to play a role in the resistance mechanism against aphids. The seeds contain high levels of antimetabolic factors (tannins, phytic acid, inhibitors of trypsin and cystatin) implied in the resistance to storage pests. High levels of the amino acid cystine are present in the seeds.

Botany Twining or trailing perennial herb; stem up to 6 m long, hairy but glabrescent. Leaves alternate, 3-foliolate; stipules up to 5 mm long; petiole up to 8.5 cm long, rachis 0.5–2 cm long; leaflets ovate-lanceolate to lanceolate, 2.5–10 cm × 0.5–4.5 cm, base rounded or cuneate to truncate, apex acute to obtuse. Inflorescence an axillary false raceme; peduncle 12–35 cm long, rachis up to 5.5 cm long, with flowers in pairs at each node. Flowers bisexual, papilionaceous, 1–2 cm long, yellow. Fruit a linear, curved pod, slightly constricted between the seeds, 5.5–8 cm long, with short curved beak. Seeds up to 4.5 mm × 3.5 mm.

Vigna comprises about 80 species. However, the tropical American species are likely to be placed in a separate genus in the near future, which would reduce the genus to 50–60 species. Important crops that belong to the genus are cowpea, mung bean, rice bean and bambara groundnut. A hairy variant of *Vigna luteola*, formerly known as *Vigna fischeri*, is common in East Africa at higher altitudes (over 1500 m).

The blue-flowered *Vigna membranacea* A.Rich. is found in DR Congo, Burundi and throughout East Africa; in Kenya the leaves are eaten after frying or boiling and are said to taste like cowpea leaves.

Vigna luteola is nonspecific in its *Rhizobium* requirement. It is day-neutral and flowers throughout the year.

Ecology *Vigna luteola* grows in swampy grasslands, among reeds on sandy lake shores,

in papyrus swamps, on stream sides and in swamp forest, from sea-level up to 2200 m altitude. It prefers an annual rainfall of 1250 mm or more.

Management As a pasture plant *Vigna luteola* does not tolerate heavy grazing or close cutting, and under such conditions will behave like an annual or short-lived perennial. Yields of 4500 kg/ha dry matter per rainy season have been reported from Zambia. In Samoa *Vigna luteola* fixed up to 126 kg/ha nitrogen in grass-legume mixtures in the first year. It is considered a weed of rice in South America, and in South Africa it figures on the national weed list. Seed harvest is difficult owing to its indeterminate flowering habit. Pods are hidden by new growth before they can be picked, and so hand harvesting has been the only method employed to date. The pods shatter.

Genetic resources and breeding An important germplasm collection of *Vigna luteola* is held at IITA, Ibadan, Nigeria. Accessions are also held at CIAT (Colombia) and ILRI (Ethiopia). *Vigna luteola* is used as a source of resistance and improved nutritive value in cowpea breeding. A method has been developed for recovery of interspecific hybrids of mung bean (*Vigna radiata* (L.) R.Wilczek) and other *Vigna* species that were previously difficult to hybridize, including *Vigna luteola*.

Prospects *Vigna luteola* can be used in breeding programmes of other *Vigna* species. As a pasture legume and cover crop it might become more important in wet and saline conditions.

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Authors C.H. Bosch

VIGNA UNGUICULATA (L.) Walp.

Protologue Repert. bot. syst. 1: 779 (1843).

Family Papilionaceae (Leguminosae - Papilionoideae, Fabaceae)

Chromosome number $2n = 22$

Synonyms *Vigna sinensis* (L.) Hassk. (1844).

Vernacular names
- Cowpea, black-eye bean (En). Niébé, haricot dolique, dolique mongette, pois yeux noirs (Fr). Caupi, feijão da China, feijão miúdo, feijão macundi, makunde (Po). Mkunde (Sw).
- Yard-long bean, asparagus bean (En). Dolique asperge, haricot kilomètre (Fr). Feijão de metro, feijão chicote, feijão espargo, feijão frade alfange (Po).
- Catjang cowpea, sowpea, Bombay cowpea (En). Dolique (Fr).

Origin and geographic distribution *Vigna unguiculata* originated in Africa, where a large genetic diversity of wild types occurs throughout the continent, southern Africa being richest. It has been introduced in Madagascar and other Indian Ocean islands, where it is sometimes found as an escape from cultivation. The greatest genetic diversity of cultivated cowpea is found in West Africa, in the savanna region of Burkina Faso, Ghana, Togo, Benin, Niger, Nigeria and Cameroon. Cowpea was probably brought to Europe around 300 BC and to India 200 BC. As a result of human selection in China, India and South-East Asia, cowpea underwent further diversification to produce two cultivar-groups, Sesquipedalis Group with long pods used as a vegetable, and Biflora Group grown for the pods, dry seeds and for fodder. Cowpea was probably introduced to tropical America in the 17th century by the Spanish and is widely grown in the United States, the Caribbean region and Brazil.

Cowpea is the most important pulse crop in the savanna regions of West and Central Africa, where it is also a valuable source of fodder. In East and southern Africa it is important both as a vegetable and as a pulse. Only in humid

Vigna unguiculata – wild and planted

Central Africa is it less prominent.

Uses Cowpea is the preferred food legume in large parts of Africa. The seed is cooked together with vegetables, spices and often palm oil, to produce a thick bean soup, which accompanies the staple food (cassava, yam, plantain). In West Africa the seed is decorticated and ground into a flour and mixed with chopped onions and spices and made into cakes which are either deep fried ('akara balls'), or steamed ('moin moin'). The flour can also be used as a basic ingredient in the preparation of many foods including baby foods. The dry seed has been used as coffee substitute. In the United States considerable amounts of immature cowpea seeds are eaten fresh.

Cowpea leaves are served boiled or fried and are usually eaten with a porridge. The leaf may be preserved by sun-drying or boiling and then sun-drying to be used during the dry season. In Botswana and Zimbabwe boiled cowpea leaves are kneaded to a pulp and squeezed into small balls, which are dried and stored. Immature, green and still soft seed is cooked to a thick soup and used as relish. The tender seedless cowpea pod is sometimes used as a cooked vegetable, as are young pods of yard-long bean. In Asia this is the most important use of cowpea, in Africa it is uncommon. In Benue State, Nigeria, the stringless coiled pods with little parchment of a landrace called 'Eje-O'Ha' are parboiled for a few minutes, opened and split in half. The seeds are eaten directly while the pod walls are dried and preserved for later use. Pods are also eaten locally in Benin.

Cowpea is used as fodder in West Africa, Asia (especially India) and Australia; it is used for grazing or cut and mixed with dry cereals for animal feed. In the United States and elsewhere cowpea is grown as a green manure crop. In Nigeria special cultivars are grown for the fibre extracted from the peduncle; the fibre is especially suited for fishing gear, and produces a good-quality paper.

A few medicinal uses of cowpea have been reported: leaves and seeds are applied as a poultice to treat swellings and skin infections, the root is used as an antidote for snakebites and to treat epilepsy, chest pain, constipation and dysmenorrhoea, and unspecified plant parts are used as a sedative in tachycardia and against various pains.

Production and international trade The total world production of dry cowpea seeds in 2002 was about 5 million t from 14 million ha, of which 64% was produced in West and Central Africa. The drier regions of Nigeria alone produced 2.1 million t from 5 million ha, and Niger produced 400,000 t from 3.5 million ha. Other main production areas are southern Africa, Central and South America, and southern Asia. There are no statistical data on the quantity of leaves and pods harvested, but it is likely to be considerable. Fresh and dried leaves are much sold in urban markets and some are traded to neighbouring countries. Dried leaves in the form of black balls are exported from Zimbabwe to Botswana and South Africa. Yard-long bean is grown in Asia on hundreds of thousands of hectares, but is of minor importance in Africa.

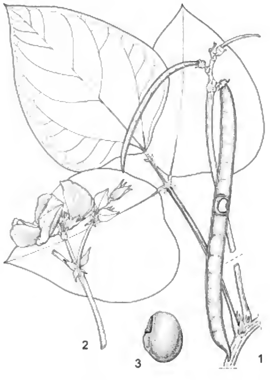
Properties The nutritional composition of leafy stem tips of cowpea per 100 g edible portion is: water 89.8 g, energy 121 kJ (29 kcal), protein 4.1 g, fat 0.3 g, carbohydrate 4.8 g, Ca 63 mg, Mg 43 mg, P 9 mg, Fe 1.9 mg, Zn 0.3 mg, vitamin A 712 IU, thiamin 0.35 mg, riboflavin 0.2 mg, niacin 1.1 mg, folate 101 μg, ascorbic acid 36 mg. Young cowpea pods with seeds contain per 100 g edible portion: water 86.0 g, energy 184 kJ (44 kcal), protein 3.3 g, fat 0.3 g, carbohydrate 9.5 g, Ca 65 mg, Mg 58 mg, P 65 mg, Fe 1.0 mg, Zn 0.3 mg, vitamin A 1600 IU, thiamin 0.15 mg, riboflavin 0.15 mg, niacin 1.2 mg, folate 53 μg, ascorbic acid 33 mg. Yard-long bean pods contain per 100 g edible portion: water 87.9 g, energy 197 kJ (47 kcal), protein 2.8 g, fat 0.4 g, carbohydrate 8.4 g, Ca 50 mg, Mg 44 mg, P 59 mg, Fe 0.5 mg, Zn 0.4 mg, vitamin A 865 IU, thiamin 0.1 mg, riboflavin 0.1 mg, niacin 0.4 mg, folate 62 μg, ascorbic acid 19 mg. Immature cowpea seeds contain per 100 g edible portion: water 77.2 g, energy 377 kJ (90 kcal), protein 3.0 g, fat 0.4 g, carbohydrate 18.9 g, fibre 5.0 g, Ca 126 mg, Mg 51 mg, P 53 mg, Fe 1.1 mg, Zn 1.0 mg, vitamin A 0 IU, thiamin 0.1 mg, riboflavin 0.15 mg, niacin 1.45 mg, folate 168 μg, ascorbic acid 2.5 mg. Mature cowpea seeds contain per 100 g edible portion: water 12.0 g, energy 1407 kJ (336 kcal), protein 23.5 g, fat 1.3 g, carbohydrate 60.0 g, fibre 10.6 g, Ca 110 mg, Mg 184 mg, P 424 mg, Fe 8.3 mg, Zn 3.4 mg, vitamin A 50 IU, thiamin 0.85 mg, riboflavin 0.25 mg, niacin 2.1 mg, folate 603 μg, ascorbic acid 1.5 mg (USDA, 2002).

The approximate fatty acid composition of fat from cowpea seeds is: saturated fatty acids 25%, monounsaturated fatty acids 8%, polyunsaturated fatty acids 42%. Cowpea protein is relatively rich in lysine, but poor in S-containing amino acids. Cowpea seed is lower

in antinutritional components such as lectins and trypsin inhibitors than common bean (*Phaseolus vulgaris* L.).

Adulterations and substitutes The pods of common bean are often used for the same dishes as yard-long bean, although the taste is not the same. Immature seeds of several leguminous plants are used as substitutes for immature cowpea seeds, e.g. those of pea (*Pisum sativum* L.), common bean and lima bean (*Phaseolus lunatus* L.).

Description Climbing, trailing or more or less erect annual or perennial herb, cultivated as an annual; taproot well developed, with many lateral and adventitious roots; stem up to 4 m long, angular or nearly cylindrical, slightly ribbed. Leaves alternate, 3-foliolate; stipules ovate, 0.5–2 cm long, spurred at base; petiole up to 15(–25) cm long, grooved above, swollen at base, rachis (0.5–)2.5–4.5(–6.5) cm long; stipels small; leaflets ovate or rhombic to lanceolate, (1.5–)7–14(–20) cm × (1–)4–10(–17) cm, basal ones asymmetrical, apical one symmetrical, entire, sometimes lobed, glabrous or slightly pubescent, 3-veined from the base. Inflorescence an axillary or terminal false raceme up to 35 cm long, with flowers clustered near the top. Flowers bisexual, papilionaceous; pedicel 1–3 mm long, with spatulate, deciduous bracteoles; calyx campanulate, tube c. 5 mm long, lobes narrowly triangular, c. 5 mm long; corolla pink to purple, sometimes white or yellowish, standard very broadly obovate, hood-shaped, c. 2.5 cm long, wings obovate, c. 2 cm long, keel boat-shaped, c. 2 cm long; stamens 10, 9 fused and 1 free; ovary superior, c. 1.5 cm long, laterally compressed, style upturned, with fine hairs in upper part, stigma obliquely globular. Fruit a linear-cylindrical pod 8–30(–120) cm long, straight or slightly curved, with a short beak, glabrous or slightly pubescent, pale brown when ripe, 8–30-seeded. Seeds oblong to almost globose, often laterally compressed, 0.5–1 cm long, black, brown, pink or white; hilum oblong, covered with a white tissue, with a blackish rim-like aril. Seedling with epigeal germination; cotyledons oblong or sickle-shaped, thick; first two leaves simple and opposite, subsequent leaves alternate, 3-foliolate.



Vigna unguiculata – 1, inflorescence; 2, fruiting branch; 3, seed.
Source: PROSEA

Other botanical information *Vigna* comprises about 80 species and occurs throughout the tropics. However, the tropical American species are likely to be placed in a separate genus in the near future, which would reduce the genus to 50–60 species.

Vigna unguiculata is extremely variable, both in wild and cultivated plants. Several subspecies (up to 10) have been distinguished, most of them comprising perennial wild types, but subsp. *unguiculata* includes annual wild types and cultivated ones.

In cultivated *Vigna unguiculata* 4 cultivar-groups are generally recognized, although the groups can be crossed readily and overlap:
- Unguiculata Group (common cowpea): pulse and vegetable types, grown for the dry or immature seeds, young pods or leaves; plant habit prostrate to erect, up to 80 cm tall, late flowering, pods 10–30 cm long, pendent, hard and firm, not inflated when young, many-seeded and seeds not spaced; most African cultivars belong to this group.
- Sesquipedalis Group (yard-long bean, synonyms: *Dolichos sesquipedalis* L., *Vigna sesquipedalis* (L.) Fruhw.): grown for the young pods; plant climbing, stem up to 4 m long, pods 30–120 cm long, pendent, inflated when young, many-seeded and seed spaced; important vegetable in South-East Asia, but of minor importance in tropical Africa, where only cultivars introduced from Asia are grown.
- Biflora Group (catjang cowpea): grown for the seeds, tender green pods and for fodder; plant habit prostrate to erect, up to 80 cm

tall, early flowering, pods 7.5–12 cm long, erect or ascending, hard and firm, not inflated when young, few-seeded and seeds not spaced; important in India and South-East Asia, locally also in Africa (e.g. Ethiopia).
- Textilis Group: a small group only grown in Nigeria for the fibre extracted from the long peduncles.

In Africa there are numerous landraces and improved cultivars within Unguiculata Group. Leaves are traditionally picked in cowpea fields grown primarily for the dry seed and belong to the top ten most popular leafy vegetables in many African countries. In addition, special types with erect plant habit or prostrate stems with long tender shoots are grown as leafy vegetable, sometimes also for the immature seeds or young pods.

Various cultivars of yard-long bean are offered by Asian seed companies, with a large variation in plant characters.

Growth and development Germination takes 3–5 days at temperatures above 22°C. Most cowpea cultivars are quantitative short-day plants, but day-neutral and long-day types exist. Flowers open in the morning and close before noon, and fall the same day. In dry climates cowpea is almost entirely self-pollinated, but in areas with high air humidity cross-pollination by insects may amount to 40%. Only fairly large insects are heavy enough to open the keel. The length of the reproductive period is very variable, with the earliest cultivars taking 30 days from planting to flowering, and less than 60 days to mature seeds. When leaves are harvested during the early growth stages, senescence starts 1.5–2 months after sowing and the plant dies after 3–4 months, depending on crop health and intensity of harvesting. Late cultivars with indeterminate growth take 90–100 days to flower and up to 210 days for the pods of the last flowers to mature.

Ecology Wild types of *Vigna unguiculata* grow in savanna vegetation, often in disturbed localities or as a weed, up to 1500 m altitude, but some can be found in grassland subject to regular burning, sandy localities close to the coast, woodland, forest edges or swampy areas, occasionally up to 2500 m altitude.

Cowpea grows best at day temperatures of 25–35°C; night temperatures should not be less than 15°C and consequently cultivation is restricted to low and medium altitudes. At altitudes above 700 m growth is retarded. Cowpea does not tolerate frost, and temperatures above 35°C cause flower and pod shedding. It performs best under full sunlight but tolerates some shade. Most cowpea for pulse is grown under rainfed conditions. Short-duration determinate types can be grown with less than 500 mm rainfall per year; in experiments in Senegal 'Ein al Ghazal' produced 2400 kg/ha of seeds with only 452 mm rain. Long-duration types require 600–1500 mm. Yard-long bean tolerates high rainfall; a fully-grown crop has a water requirement of 6–8 mm per day. Cultivation in the dry season with ample irrigation is practised, as well as cultivation during the rainy season, although sowing during the rainy season can result in damage to the emerging or young plants. Cowpea can be grown on a wide range of soil types with pH 5.5–6.5(–7.5), provided they are well drained.

Propagation and planting Farmers normally use farm-saved seed for planting. The 1000-seed weight of cowpea is 150–300 g. The seed rate for pure stands is 15–30 kg/ha. Seed dressing with an insecticide and a fungicide (e.g. thiram) prior to planting is recommended. In tropical Africa cowpea is grown either intercropped or in relay with other crops such as yam, maize, cassava, groundnut, sorghum or pearl millet. Pure stands are not common except in the coastal areas of East Africa, and also in Asia and Western countries. Field spacing varies according to growth habit and cropping system. Erect types are spaced at about 10 cm within the row and 50–100 cm between rows. Where hill planting is practised in West Africa, a spacing of 50 cm × 50–60 cm is used for erect cultivars. The spacing for prostrate indeterminate cultivars for leaf production is about 75 cm × 75 cm. Cowpea requires land with fine tilth for good root growth. Generally, deep ploughing followed by harrowing provides an adequate tilth. In intercropping systems, tillage normally follows the crop in which cowpea is interplanted.

Peri-urban vegetable farmers use special cultivars for ratoon cropping of the leaves. They broadcast the seed on raised beds, made on well-manured soil, aiming at a dense stand of about 25 plants per m^2.

Farmers in Africa use yard-long bean seed harvested from a previous crop, in contrast to South-East Asia, where many farmers procure healthy seed from improved cultivars. The 1000-seed weight of yard-long bean is lower than that of cowpea, 100–150 g. Seed is sown in pockets of 2–4 seeds. Cultivation is usually on raised beds for good drainage and easy surface irrigation and for easy staking and har-

vesting. Earthing-up the young plants protects the shallow root system and gives support to the seedlings. Some farmers apply mulch of rice straw, but this is not a common practice.

Management Cowpea derives a significant amount of its nitrogen requirements from the atmosphere and may leave 75–150 kg/ha in the soil for the benefit of the succeeding crop. It forms N-fixing nodules with *Sinorhizobium fredii* and several *Bradyrhizobium* species. If cowpea is grown in localities where it has not been grown recently, inoculation with nitrogen-fixing bacteria has been found to be beneficial. Cowpea requires phosphorus for nodulation and root growth. Incorporation of 25 kg/ha P is adequate for plant growth in phosphorus-deficient soils. In soils known to be deficient in potassium, application of 25 kg/ha K is recommended. Cowpea must be kept weed free during the early stages of growth, up to 8 weeks after emergence of the seedlings.

Cowpea grown as a vegetable and yard-long bean have a high mineral uptake. In soils of average fertility an application is recommended of 5–10 t/ha of farmyard manure during soil preparation, together with N 20 kg/ha, K 25 kg/ha and P 40 kg/ha. Three weeks after emergence a top dressing of 50 kg/ha urea is given. In yard-long bean, 2–2.5 m long stakes are inserted near the seed beds before sowing or during the first two weeks after emergence, before the plants have reached a height of 30 cm. A cheap method of staking is to relay-plant yard-long bean next to the stems of maize before or just after the cobs are harvested. Weeding by superficial hand hoeing is only needed during the first month. Once the crop is fully grown it outcompetes weeds.

Diseases and pests Cowpea is susceptible to a wide range of diseases and pests. Yard-long bean suffers from the same diseases and pests but seems less susceptible than cowpea under humid conditions. Fungal diseases are more troublesome during the rainy season, whereas insect and mite pests and virus diseases cause more damage during the dry season.

The major fungal diseases are anthracnose (*Colletotrichum lindemuthianum*), blight (*Ascocyta phaseolorum*), brown blotch (*Colletotrichum* ssp.), leaf smut (*Protomycopsis phaseoli*), leaf spot (*Cercospora* spp., *Septoria vignae*, *Pseudocercospora cruenta*), brown rust (*Uromyces* spp.), scab (*Elsinoe phaseoli*), powdery mildew (*Erysiphe polygoni*), pythium soft stem rot (*Pythium aphanidermatum*), stem canker (*Macrophomina phaseolina*) and web blight (*Rhizoctonia solani*). Crop rotation and the use of chemicals and resistant cultivars are necessary for integrated disease control. Bacterial diseases include bacterial blight (*Xanthomonas campestris*), which occurs worldwide, and bacterial pustules (*Xanthomonas* spp.) reported from Nigeria. These bacteria are seed-transmitted and secondary spread occurs by wind-driven rain. Control measures include the use of pathogen-free seeds, seed treatment with a mixture of antibiotics and fungicides such as streptocycline plus captan, and strict crop rotation.

Many viruses attack *Vigna unguiculata*. Some viruses of economic importance are cowpea aphid-borne mosaic potyvirus (CABMV), cowpea mottle carmovirus (CPMoV), cowpea yellow mosaic virus (CYMV), black eye cowpea mosaic potyvirus or bean common mosaic potyvirus (BCMV), cucumber mosaic cucumovirus (CMV-CS) and cowpea golden mosaic virus (CPGMV). Some of the viruses are seedborne, while aphids, white flies and beetles perform field transmission. Control measures include use of healthy seed of resistant cultivars if available, and weeding to remove alternative hosts. In poor sand soils, cowpea is attacked by root-knot nematodes (*Meloidogyne* spp).

In tropical Africa much damage is caused by cowpea aphids (*Aphis craccivora*), flower thrips (*Megalurothrips sjostedti*), legume pod borers (*Maruca vitrata*, *Etiella zinckenella*), pod bugs and seed suckers (e.g. *Clavigralla tomentosicollis*, synonym: *Acanthomia tomentosicollis*). Lygus beetle (*Lygus hesperus*), cowpea curculio (*Chalcodermus aeneus*) and green leafhoppers (*Empoasca* spp.) are of less importance. Yard-long bean is especially attractive to aphids (*Myzus persicae*, *Aphis gossypii*), green stink bug (*Nezara viridula*) and red spider mite (*Tetranychus* spp.); greasy cutworms (*Agrotis ipsilon*) often cause damage just after emergence. The bean shoot fly (*Ophiomyia phaseoli*) is a common pest; the larvae tunnel in the leaves and stems, and severely attacked young plants will die, whereas older plants will suffer from hampered growth and serious yield reduction. Another common pest is the bean pod fly (*Melanogromyza sojae*). The larvae damage the petioles and young pods. Control involves protecting the seed with a systemic insecticide (e.g. carbofuran) at sowing or applied as a solution to the emerging seedlings in the planting holes. Plant debris and affected plants must be burned. Cowpea seeds are extremely vulnerable to storage pests, with the cosmopolitan

cowpea weevil (*Callosobruchus maculatus*) being the major storage pest. Measures to reduce pest damage include application of inoffensive vegetable oil, neem (*Azadirachta indica* A.Juss.) oil or wood ash, roasting and bagging the seeds in air-tight plastic bags, and storing as whole pods.

Use of chemicals, resistant cultivars, biological control and proper crop management such as intercropping and weeding are necessary for integrated pest management. Chemical control of insects is common practice on yard-long bean, but not on cowpea. Because of the risks for farmer and consumer (especially when leaves are harvested), these sprayings must be reduced to the strict minimum.

Two parasitic weeds are a serious problem: *Alectra vogelii* Benth. prevalent in the southern savanna regions of West Africa, East Africa and southern Africa, and *Striga gesnerioides* (Willd.) Vatke prevalent in the savanna regions of West and Central Africa. Crop rotation, deep cultivation, intercropping, early planting and use of resistant cultivars reduce infestation by these parasitic weeds.

Harvesting Cowpea leaves are picked in a period from 4 weeks after emergence of the seedlings to the onset of flowering. In crops grown for the seed, farmers often harvest 10–20% of the leaves before the start of flowering with little detrimental effect on the seed yield. Stronger defoliation increasingly reduces flowering, fruiting and seed yield. Growers of leafy cowpea types cut the plants at about 10 cm above the ground for a succession of new shoots (ratooning). Green pods are harvested when the seed is still immature, 12–15 days after flowering. Harvesting of dry seed is done when at least two thirds of the pods are dry and yellow. In indeterminate types harvesting is complicated by prolonged and uneven ripening. For hay, the whole plant is cut and rolled into a bundle.

The first picking of yard-long bean pods in the desirable stage takes place 6–7 weeks after planting, depending on cultivar and market requirements. Normally the pods are picked when the outline of the seeds is just visible. Picking must be meticulous, because pods which are passed over until the next harvest will become tough and discoloured, with swollen seed, and may exhaust the plant. Successive harvests take place at least once a week (twice a week for a better tuned grading) during 4–8 weeks.

Yield Farmers may harvest up to 400 kg/ha of cowpea leaves in a few rounds with no noticeable reduction of seed yields. In Nigeria climbing cultivars have yielded 9–17 t/ha of fresh pods, whereas decumbent cultivars yielded 6–15 t/ha. The mean dry seed yield of the same cultivars was 1.4–1.7 t/ha. The world average yield of dry cowpea seed is low, 240 kg/ha, and for fodder it is 500 kg/ha (air-dried leafy stems). The average seed yield in Senegal is 110 kg/ha, in Niger 470 kg/ha, in Nigeria and Ghana 600 kg/ha, and in the United States 900 kg/ha. A yield potential of 3 t/ha of seed and 4 t/ha of hay can be achieved with good management.

For yard-long bean, a total yield of 15 t/ha in a harvest period of at least one month is considered satisfactory, but yields as high as 30 t/ha have been reported.

Handling after harvest Harvested leaves cannot be kept for long; they have to be sold within 2 days. The shoots can be kept longer by putting them in a basin with water. Cowpea leaves are frequently dried in the sun for preservation, either after boiling and squeezing to black balls, or directly as whole or broken leaves, or as powder. Green pods are tied in bundles of 20–40 and packed in baskets or crates for transport to the market. Yard-long bean is less susceptible to loss of weight by transpiration and to transport damage than most other vegetables. In cool storage (8°C) the pods will keep for 4 weeks. Immature fresh cowpea seeds have a limited shelf-life if stored at ambient temperatures, but at 8°C they can stay fresh for 8 days. In Europe, the United States and Japan, immature tender green pods are sometimes frozen or canned. As a pulse, the threshed seed should be dried thoroughly to a moisture content of 14% or less for good storability.

Genetic resources The International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria holds a collection of over 15,000 accessions of the cultivated cowpea and 1000 accessions of related wild *Vigna*; the University of California, Riverside, United States holds 5000 accessions. IITA characterized 8500 accessions for resistance to *Maruca* pod borer and sucking bugs, and 4000 for resistance to flower thrips, bruchids and viruses. The level of resistance to insect pests is high in the wild species *Vigna vexillata* (L.) A.Rich., especially to pod sucking bugs and *Maruca* pod borer. Many accessions of wild *Vigna* species possess high levels of resistance to the storage weevil.

Small collections of yard-long bean are present

at the Asian Vegetable Research and Development Center (AVRDC), Shanhua, Taiwan and the Institute of Crop Germplasm Resources (CAAS), Beijing, China and in national institutes in Asia. Only very small collections of catjang cowpea exist. In Asia landraces of vegetable and pulse types of *Vigna unguiculata* are in danger of being lost since improved cultivars are widely grown. This process has also started in Africa.

Breeding Much work has been performed on *Vigna unguiculata* breeding, mostly for cultivars grown as pulse, and in South-East Asia for yard-long bean. In the United States special cowpea cultivars for harvesting pods and young seeds have been developed. Selection criteria for cowpea concern resistances (to insect pests, diseases, nematodes, parasitic weeds, drought), plant type, seed type, yield and cropping system. IITA has a large breeding programme and distributes cowpea germplasm, breeding material and cultivars. National programmes in many countries have released improved cowpea cultivars with many resistance genes, e.g. to bacterial blight, cowpea aphid-borne mosaic potyvirus, cowpea aphids, cowpea curculio, root-knot nematodes, cowpea weevil and parasitic weeds. New early maturing cultivars were developed for hot and dry conditions, e.g. 'Ein al Ghazal' and 'Mouride'. Unfortunately, improved cultivars are often short, erect, determinate types selected for optimal dry seed production and less suitable for the traditional leaf picking. Wild African *Vigna* species have been successfully crossed with *Vigna unguiculata*. Molecular markers are being used. Breeding work on African vegetable types is scarce. Simlaw Seeds in Kenya has commercialized 'Kenduke-1', a semi-trailing type selected for large leaves with an attractive green colour and good taste and that can be picked for a long time. In Senegal the leaf vegetable 'Fuuta' with a vegetative period of up to 50 days was selected. The Crop Breeding Institute in Harare, Zimbabwe, selected dual-purpose cultivars with high leaf and seed yield; the Zimbabwean cultivar 'Chigwa' is specially suited for use as leaf vegetable because of late flowering. 'Melakh' is a dual-purpose cultivar bred for dry and fresh seed production in Senegal.
Breeding of improved cultivars of yard-long bean by backcrossing and pedigree selection has been performed in South-East Asia. Yield is strongly correlated with pod length and the number of pods per plant. Resistance to bean flies would be welcome but seems difficult to achieve. East-West Seed Company in Thailand selected cultivars adapted to a wide range of growing conditions, e.g. 'Aba', with early maturity (first harvest 45 days after sowing), high yield, greyish green pods 60–70 cm long, and excellent market quality.

Prospects The prospects for vegetable cowpea in Africa are bright. Apart from traditional dual-purpose cowpea cultivars (harvested as pulse and for the leaves) there is a need for special vegetable types: as a leaf vegetable: dwarf plants with erect or prostrate habit, long vegetative period, tender shoots and leaves; for immature seed: dwarf plants with erect or prostrate, determinate habit; and for fresh pods about 15 cm long (replacing French bean in hot lowland regions).
As a fruit vegetable, it seems logical to replace cowpea by yard-long bean, because of its superior yield and quality. Asian cultivars should be tested on suitability for tropical African conditions because, if combined with market development, yard-long bean has the potential to become an excellent enrichment of the available vegetable assortment.

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ZORNIA GLOCHIDIATA C.Rchb. ex DC.

Protologue Prodr. 2: 316 (1825).

Family Papilionaceae (Leguminosae - Papilionoideae, Fabaceae)

Chromosome number $2n = 20$

Synonyms *Zornia diphylla* auct. non (L.) Pers.

Vernacular names Herbe mouton (Fr).

Origin and geographic distribution *Zornia glochidiata* is widespread in sub-Saharan Africa, from Senegal east to Eritrea and south to South Africa, also in Madagascar.

Uses The leaves of *Zornia glochidiata* are collected from the wild and eaten cooked in sauces with rice or couscous. *Zornia glochidiata* is a good soil binder, e.g. on bunds of paddy-fields. It is considered a good fodder plant, being of importance especially in the Sahel region, although it may cause bloat in cattle. The leaves are taken as a laxative. In Kenya cooked leaves are given to children suffering from kwashiorkor. In Congo sap from the plant is used as eye drops against epilepsy, and the root is eaten as an aphrodisiac. In Zimbabwe the roots are used to treat venereal diseases, to prevent abortion and to ease childbirth.

Botany Annual herb with erect or decumbent stems up to 45(–70) cm long. Leaves alternate, 2-foliolate; stipules lanceolate, up to 1.5 cm long, spurred; petiole 0.5–2 cm long; leaflets lanceolate to ovate-lanceolate, up to 4.5 cm × 1.5 cm, acute and shortly mucronate at apex, glabrous to pubescent beneath, sparsely glandular-punctate. Inflorescence a spike up to 20 cm long; peduncle 1–5 cm long; bracts paired, ovate to elliptical, up to 1.5 cm long. Flowers bisexual, papilionaceous; calyx hyaline, tube c. 1.5 mm long, lobes 5, up to 1.5 mm long, 2 upper lobes connate; petals yellow, pink or crimson, often with red veins, standard up to 6 mm long; stamens 10, filaments united below into a closed tube; ovary superior, 1-celled, style curved. Fruit a jointed pod up to 2 cm long, covered with spreading bristles, 2–5-seeded. Seeds compressed reniform, c. 1.5 mm long, brown.

Zornia is a pantropical genus of about 80 species, of which 13 are native and 1 introduced in Africa. *Zornia glochidiata* and other African *Zornia* species were long confused with *Zornia diphylla* (L.) Pers., which is restricted to Sri Lanka and southern India. Probably other *Zornia* species are used in tropical Africa as a vegetable in a similar way as *Zornia glochidiata*.

Zornia glochidiata plants wilt after the rainy season and disintegrate quickly. The roots have nitrogen-fixing root nodules.

Ecology *Zornia glochidiata* is common in sandy areas with annual rainfall of at least 300 mm during the rainy season. It is an important component of Sahel and Sudano-Sahel grasslands. Around drinking places in northern Senegal it may form a continuous mat of vegetation during the rainy season. In East and southern Africa it occurs in grassland, open woodland, wasteland and former cultivation areas, up to 1800 m altitude.

Genetic resources and breeding *Zornia glochidiata* is widespread and common and not in danger of genetic erosion. CIAT, Cali, Colombia holds a collection of *Zornia* germplasm including 15 accessions of *Zornia glochidiata*.

Prospects *Zornia glochidiata* will probably remain a vegetable of minor importance only. It is likely to remain important as a forage that is part of the natural vegetation.

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Vegetables with other primary use

List of species in other commodity groups (parenthesis), which are used also as vegetable. Synonyms in the indented lines. (21 June 2004)

Abelmoschus ficulneus (fibres)
Abelmoschus moschatus (essential oils and exudates)
  Hibiscus abelmoschus
Abrus precatorius (medicinal plants)
Abutilon angulatum (fibres)
Abutilon longicuspe (fibres)
Abutilon mauritianum (fibres)
  Pavonia patens
Acacia amythethophylla (ornamentals)
  Acacia macrothyrsa
Acacia bussei (fuel plants)
Acacia drepanolobium (forages)
Acacia farnesiana (essential oils and exudates)
Acacia fleckii (forages)
  Acacia cinerea
Acacia gerrardii (fibres)
  Acacia hebecladoides
Acacia nilotica (dyes and tannins)
  Acacia adansonii
  Acacia arabica
  Acacia subulata
Acacia sieberiana (essential oils and exudates)
Acacia tortilis (forages)
  Acacia raddiana
  Acacia spirocarpa
Acalypha ciliata (medicinal plants)
Acalypha fruticosa (medicinal plants)
Acalypha ornata (medicinal plants)
Acanthopale laxiflora (ornamentals)
Achyranthes aspera (medicinal plants)
Acmella caulirhiza (medicinal plants)
  Spilanthes filicaulis
Acmella uliginosa (medicinal plants)
  Spilanthes iabadicensis
  Spilanthes uliginosa
Acrostichum aureum (medicinal plants)
Adenia cissampeloides (medicinal plants)
  Adenia gracilis
  Adenia gummifera
  Adenia reticulata
Adenia ellenbeckii (medicinal plants)
Adenia lobata (medicinal plants)
  Adenia mannii
  Adenia rumicifolia
Aeollanthus pubescens (spices and condiments)
Aerva javanica (medicinal plants)
  Aerva persica
Aerva lanata (medicinal plants)
Aerva leucura (medicinal plants)
Aeschynomene nilotica (forages)
Afzelia africana (timbers)
Afzelia bella (timbers)
Afzelia quanzensis (timbers)
Agelaea paradoxa (medicinal plants)
  Castanola paradoxa
Ageratum conyzoides (medicinal plants)
  Ageratum houstonianum
Albizia adianthifolia (medicinal plants)
Albizia zygia (timbers)
  Acacia zygia
Albuca abyssinica (medicinal plants)
  Albuca wakefieldii
Allophylus rubifolius (medicinal plants)
  Allophyllus alnifolius
Aloe buettneri (medicinal plants)
Aloe macrocarpa (auxiliary plants)
Aloe nuttii (medicinal plants)
Aloe schweinfurthii (medicinal plants)
Alpinia zerumbet (essential oils and exudates)
  Alpinia speciosa
Alternanthera tenella (ornamentals)
  Alternanthera bettzickiana
  Alternanthera ficoidea
Amaranthus caudatus (cereals and pulses)
Ampelopteris prolifera (medicinal plants)
  Ampelopteris elegans
  Goniopteris prolifera
  Hemionitis prolifera
Amphiblemma molle (ornamentals)
  Amphiblemma riparium
Amphiblemma setosum (ornamentals)
Anacardium occidentale (fruits)
Ananas comosus (fruits)
  Ananas sativus
Arachis hypogaea (cereals and pulses)
Ardisia humilis (medicinal plants)
  Ardisia solanacea
Argemone mexicana (medicinal plants)
Artocarpus heterophyllus (fruits)
Asparagus racemosus (medicinal plants)
Averrhoa carambola (fruits)
Azadirachta indica (auxiliary plants)
Bacopa monnieri (medicinal plants)
Baikiaea insignis (ornamentals)
Balanites aegyptiaca (fruits)
Balanites gillettii (fruits)
Bambusa vulgaris (timbers)

Barteria fistulosa (medicinal plants)
Bauhinia petersiana (medicinal plants)
Bauhinia purpurea (ornamentals)
Bauhinia variegata (ornamentals)
Berrya africana (timbers)
  Carpodiptera africana
Blutaparon vermiculare (auxiliary plants)
  Philoxerus vermicularis
Blyttia fruticulosum (medicinal plants)
  Cynanchum defoliascens
Boerhavia coccinea (medicinal plants)
Boerhavia diffusa (medicinal plants)
  Boerhavia africana
  Commicarpus africanus
Bombax buonopozense (fibres)
Bombax costatum (fibres)
Borassus aethiopum (fruits)
Borassus flabellifer (carbohydrates)
Borassus sambiranensis (fruits)
Boscia salicifolia (medicinal plants)
Boscia senegalensis (fruits)
  Boscia octandra
Brassica nigra (spices and condiments)
Cadaba farinosa (medicinal plants)
Cajanus cajan (cereals and pulses)
  Cajanus indicus
Cajanus scarabaeoides (auxiliary plants)
  Atylosa scarabaeoides
Calamus deerratus (fibres)
Calycobolus africanus (medicinal plants)
Capparis decidua (spices and condiments)
Capparis fascicularis (medicinal plants)
  Capparis elaeagnoides
  Capparis rothii
Capparis sepiaria (fruits)
Capparis tomentosa (medicinal plants)
  Capparis polymorpha
Capsella bursa-pastoris (medicinal plants)
Cardiospermum grandiflorum (medicinal plants)
Cardiospermum halicacabum (medicinal plants)
Carica papaya (fruits)
Carpolobia alba (timbers)
  Carpolobia glabrescens
Carpolobia lutea (timbers)
Cassia javanica (ornamentals)
  Cassia agnes
  Cassia nodosa
Ceiba pentandra (fibres)
  Eriodendron anfractuosum
Celosia schweinfurthiana (medicinal plants)
Celtis toka (auxiliary plants)
  Celtis integrifolia
Celtis zenkeri (timbers)
Centaurea perrottetii (medicinal plants)
Centella asiatica (medicinal plants)
  Hydrocotyle asiatica
Ceropegia fusiformis (carbohydrates)
Chasmanthera dependens (medicinal plants)
Chasmanthera welwitschii (medicinal plants)
Chenopodium opulifolium (forages)
Chlamydocola chlamydantha (timbers)
  Cola chlamydantha
Chlorophytum subpetiolatum (medicinal plants)
  Anthericum subpetiolatum
Chrysanthemum coronarium (medicinal plants)
Cichorium intybus (stimulants)
Cissus populnea (carbohydrates)
Cissus quadrangularis (fibres)
  Cissus fischeri
  Vitis quadrangularis
Cissus rotundifolia (fibres)
Cistanche phelypaea (carbohydrates)
Citrullus colocynthis (medicinal plants)
  Colocynthis vulgaris
Clematis simensis (medicinal plants)
Clerodendrum volubile (ornamentals)
Coccinia abyssinica (carbohydrates)
Cocculus pendulus (medicinal plants)
Cocos nucifera (vegetable oils)
Cola brevipes (medicinal plants)
Cola heterophylla (fruits)
Cola lateritia (timbers)
Combretum adenogonium (medicinal plants)
  Combretum fragrans
  Combretum ghasalense
  Combretum ternifolium
Combretum glutinosum (medicinal plants)
Combretum mooreanum (medicinal plants)
Combretum padoides (medicinal plants)
Combretum paniculatum (medicinal plants)
Combretum platypterum (medicinal plants)
Combretum racemosum (ornamentals)
Commelina diffusa (forages)
  Commelina nudiflora
  Murdannia nudiflora
Conocarpus erectus (dyes and tannins)
Conyza aegyptiaca (medicinal plants)
Corchorus aestuans (fibres)
  Corchorus acutangulus
Corchorus fascicularis (forages)
Coriandrum sativum (spices and condiments)
Costus lucanusianus (medicinal plants)
Crambe hispanica (vegetable oils)
  Crambe abyssinica
Craterispermum cerinanthum (dyes and tannins)
Crateva adansonii (fruits)
Crotalaria atrorubens (forages)
Crotalaria cylindrocarpa (auxiliary plants)

Crotalaria glauca (medicinal plants)
Crotalaria natalitia (medicinal plants)
Crotalaria pallida (auxiliary plants)
Crotalaria falcata
Crotalaria mucronata
Crotalaria striata
Crotalaria retusa (auxiliary plants)
Crotalaria senegalensis (forages)
Cryptolepis sanguinolenta (dyes and tannins)
Cucumis dipsaceus (medicinal plants)
Cyamopsis tetragonoloba (forages)
Cyathula orthocantha (medicinal plants)
Cyathula prostrata (medicinal plants)
Cyathula pedicellata
Cyclosorus gongylodes (medicinal plants)
Cynoglossum lanceolatum (medicinal plants)
Cyperus esculentus (carbohydrates)
Cyperus papyrus (fibres)
Cyphia glandulifera (carbohydrates)
Cyphomandra betacea (fruits)
Dalbergia nitidula (timbers)
Daniellia oliveri (essential oils and exudates)
Delonix elata (ornamentals)
Desplatsia dewevrei (fruits)
Desplatsia subericarpa (fibres)
Detarium microcarpum (medicinal plants)
Detarium senegalense (timbers)
Dialium dinklagei (fuel plants)
Dicellandra barteri (ornamentals)
Dicliptera laxata (medicinal plants)
Dioscorea minutiflora (carbohydrates)
Dioscorea odoratissima (carbohydrates)
Dioscorea liebrechtsiana
Diospyros mespiliformis (fruits)
Dolichos schweinfurthii (ornamentals)
Dolichos trilobus (auxiliary plants)
Dombeya burgessiae (fibres)
Dombeya dawei
Dombeya platypoda
Dorstenia kameruniana (medicinal plants)
Craterogyne kameruniana
Trymatococcus kamerunianus
Dracaena mannii (ornamentals)
Dracaena perrottetii
Dracaena usambarensis
Dregea abyssinica (ornamentals)
Drimia indica (medicinal plants)
Scilla indica
Urginea indica
Drymaria cordata (medicinal plants)
Dypsis decipiens (ornamentals)
Chrysalidocarpus decipiens
Dypsis madagascariensis (timbers)
Chrysalidocarpus oleraceus
Dypsis perrieri (fibres)
Chrysalidocarpus auriculatus
Dypsis pinnatifrons (ornamentals)
Dypsis gracilis
Dypsis tanalensis (fibres)
Neodypsis tanalensis
Dypsis utilis (fibres)
Vonitra utilis
Echinochloa colona (forages)
Panicum colonum
Echinochloa crus-galli (forages)
Eclipta prostrata (medicinal plants)
Eclipta alba
Ectadiopsis oblongifolia (fibres)
Cryptolepis nigritana
Cryptolepis oblongifolia
Eichhornia crassipes (auxiliary plants)
Elaeis guineensis (vegetable oils)
Eleusine coracana (cereals and pulses)
Embelia schimperi (medicinal plants)
Emilia sonchifolia (medicinal plants)
Ensete ventricosum (carbohydrates)
Ensete edule
Musa ensete
Musa ventricosa
Entada rheedei (fibres)
Entada pursaetha
Enterolobium cyclocarpum (ornamentals)
Enydra fluctuans (spices and condiments)
Eremomastax speciosa (medicinal plants)
Eremomastax polysperma
Paulowilhelmia speciosa
Eriosema glomeratum (medicinal plants)
Eriosema laurentii (medicinal plants)
Erythrina fusca (auxiliary plants)
Erythrina glauca
Erythrina variegata (auxiliary plants)
Erythrina indica
Erythrococca menyhartii (fruits)
Etlingera elatior (ornamentals)
Euadenia trifoliolata (medicinal plants)
Euphorbia balsamifera (ornamentals)
Euphorbia hirta (medicinal plants)
Chamaesyce hirta
Euphorbia pulcherrima (ornamentals)
Fadogia cienkowskii (fruits)
Feretia apodanthera (medicinal plants)
Feretia canthioides
Ferula communis (medicinal plants)
Ficus capreifolia (fibres)
Ficus dicranostyla (ornamentals)
Ficus elastica (ornamentals)
Ficus glumosa (dyes and tannins)
Ficus sonderi
Ficus ingens (auxiliary plants)
Ficus katagumica
Ficus kawuri
Ficus mucuso (ornamentals)

Ficus sur (timbers)
Ficus capensis
Ficus mallotocarpa
Ficus riparia
Ficus sycomorus (fruits)
Ficus gnaphalocarpa
Ficus vallis-choudae (fruits)
Flacourtia indica (fruits)
Flacourtia flavescens
Flemingia macrophylla (auxiliary plants)
Foeniculum vulgare (spices and condiments)
Anethum foeniculum
Gaertnera paniculata (timbers)
Girardinia diversifolia (fibres)
Girardinia condensata
Girardinia heterophylla
Glinus lotoides (medicinal plants)
Glinus oppositifolius (medicinal plants)
Gliricidia sepium (auxiliary plants)
Globimetula braunii (medicinal plants)
Glossonema boveanum (forages)
Glossonema nubicum
Glycine max (cereals and pulses)
Soja hispida
Glyphaea brevis (auxiliary plants)
Gomphocarpus fruticosus (fibres)
Asclepias decipiens
Asclepias fruticosa
Gomphrena globosa (ornamentals)
Gongronema latifolium (medicinal plants)
Marsdenia latifolia
Gouania longispicata (medicinal plants)
Grangea maderaspatana (medicinal plants)
Grewia bicolor (timbers)
Grewia brunnea (medicinal plants)
Grewia carpinifolia (forages)
Grewia hookerana (medicinal plants)
Grewia mollis (timbers)
Grewia pubescens
Grewia tenax (fruits)
Guiera senegalensis (medicinal plants)
Guizotia abyssinica (vegetable oils)
Gymnema sylvestre (medicinal plants)
Heinsia crinita (fruits)
Heinsia pulchella
Heliotropium zeylanicum (medicinal plants)
Heliotropium subulatum
Heterotis canescens (medicinal plants)
Dissotis canescens
Heterotis rotundifolia (medicinal plants)
Dissotis rotundifolia
Hibiscus diversifolius (fibres)
Hibiscus ludwigii (fibres)
Hibiscus lunariifolius (fibres)
Hibiscus micranthus (fibres)
Hibiscus panduriformis (fibres)
Hibiscus physaloides (medicinal plants)
Hibiscus rosa-sinensis (ornamentals)
Hibiscus rostellatus (medicinal plants)
Hilleria latifolia (medicinal plants)
Hydrocotyle bonariensis (auxiliary plants)
Hydrocotyle sibthorpioides (ornamentals)
Hygrophila auriculata (medicinal plants)
Hygrophila spinosa
Hyphaene coriacea (carbohydrates)
Hyphaene hildebrandtii
Hyphaene natalensis
Hyphaene shatan
Hyphaene crinita (fruits)
Hyphaene petersiana (carbohydrates)
Hyphaene benguellensis
Hyphaene ventricosa
Hyphaene thebaica (timbers)
Hypoestes cancellata (medicinal plants)
Hypoestes forskaolii (medicinal plants)
Hyptis pectinata (medicinal plants)
Hyptis suaveolens (medicinal plants)
Impatiens balsamina (ornamentals)
Impatiens sakerana (ornamentals)
Indigofera arrecta (dyes and tannins)
Ipomoea alba (ornamentals)
Calonyction aculeatum
Ipomoea batatas (carbohydrates)
Ipomoea cairica (ornamentals)
Ipomoea palmata
Ipomoea involucrata (auxiliary plants)
Ipomoea pes-caprae (auxiliary plants)
Ipomoea purpurea (ornamentals)
Ipomoea quamoclit (ornamentals)
Quamoclit pennata
Isoberlinia tomentosa (timbers)
Isoberlinia dalzielii
Isoglossa lactea (medicinal plants)
Jasminum fluminense (ornamentals)
Jasminum mauritianum
Juncus rigidus (fibres)
Kedrostis foetidissima (medicinal plants)
Kleinhovia hospita (ornamentals)
Kosteletzkya grantii (fibres)
Laccosperma secundiflorum (fibres)
Ancistrophyllum secundiflorum
Lannea acida (medicinal plants)
Lannea microcarpa (fibres)
Laportea aestuans (fibres)
Fleurya aestuans
Lasianthera africana (medicinal plants)
Leptadenia pyrotechnica (fuel plants)
Leucaena esculenta (ornamentals)
Leucaena leucocephala (auxiliary plants)
Leucaena glauca
Leucas martinicensis (medicinal plants)
Limonium sinuatum (ornamentals)

Lobelia anceps (medicinal plants)
Loeseneriella clematoides (fibres)
Lomariopsis guineensis (medicinal plants)
Lonchocarpus laxiflorus (dyes and tannins)
Ludwigia stolonifera (forages)
  Jussiaea repens
  Ludwigia adscendens
Luffa cylindrica (fibres)
  Luffa aegyptiaca
Lycium europaeum (forages)
Lygodium microphyllum (ornamentals)
Maerua angolensis (medicinal plants)
Maerua crassifolia (timbers)
Maerua pseudopetalosa (medicinal plants)
  Courbonia virgata
Maesa lanceolata (medicinal plants)
Maesa nuda (medicinal plants)
Malva parviflora (medicinal plants)
Mangifera indica (fruits)
  Fegimanra africana
Manihot esculenta (carbohydrates)
  Manihot utilissima
Manihot glaziovii (essential oils and exudates)
Mariscus rubrotinctus (medicinal plants)
  Cyperus distans
Maytenus arbutifolia (auxiliary plants)
  Maytenus serrata
Maytenus senegalensis (timbers)
  Gymnosporia senegalensis
Maytenus undata (timbers)
Megaphrynium macrostachyum (fibres)
  Sarcophrynium arnoldianum
Melanthera scandens (medicinal plants)
  Melanthera brownei
Melastomastrum afzelii (ornamentals)
  Dissotis paucistellata
Melia azedarach (timbers)
Merremia umbellata (auxiliary plants)
Microdesmis puberula (medicinal plants)
  Microdesmis zenkeri
Microglossa afzelii (medicinal plants)
Mikania chevalieri (medicinal plants)
Mikania sagittifera (medicinal plants)
  Mikania scandens
Mollugo cerviana (forages)
Mollugo nudicaulis (medicinal plants)
Mollugo pentaphylla (medicinal plants)
Momordica cissoides (medicinal plants)
Mondia whitei (medicinal plants)
Morus alba (forages)
Mucuna pruriens (auxiliary plants)
  Mucuna aterrima
  Mucuna cochinchiniensis
  Mucuna nivea
Mucuna sloanei (dyes and tannins)
Mussaenda arcuata (medicinal plants)
Mussaenda landolphioides (ornamentals)
Myrianthus libericus (fruits)
Myrianthus serratus (fruits)
Neonotonia wightii (forages)
  Glycine wightii
Neorautanenia mitis (medicinal plants)
  Neorautanenia pseudopachyrhiza
Nephrolepis biserrata (ornamentals)
Neptunia oleracea (medicinal plants)
Neuropeltis acuminata (fibres)
Nicandra physalodes (fruits)
Normandiodendron romii (timbers)
  Leonardoxa romii
Nymphaea lotus (carbohydrates)
Nymphaea nouchali (carbohydrates)
  Nymphaea caerula
  Nymphaea calliantha
  Nymphaea capensis
Nymphoides indica (ornamentals)
Ocimum americanum (essential oils and exudates)
  Ocimum canum
  Ocimum graveolens
Ocimum basilicum (spices and condiments)
Ocimum gratissimum (essential oils and exudates)
  Ocimum suave
  Ocimum urticifolium
  Ocimum viride
Oldenlandia corymbosa (medicinal plants)
  Oldenlandia caespitosa
Oldenlandia lancifolia (medicinal plants)
Opilia amentacea (medicinal plants)
  Opilia celtidifolia
Opuntia ficus-indica (fruits)
Ormocarpum kirkii (medicinal plants)
Osmunda regalis (ornamentals)
Ottelia ulvifolia (medicinal plants)
Oxalis anthelmintica (spices and condiments)
Oxalis corniculata (medicinal plants)
  Oxalis radicosa
Oxalis pes-caprae (spices and condiments)
Oxytenanthera abyssinica (timbers)
  Oxytenanthera borzii
Pachira glabra (vegetable oils)
  Bombacopsis glabra
Pachyrhizus erosus (carbohydrates)
Pancratium trianthum (ornamentals)
Pandanus utilis (fibres)
  Vinsonia utilis
Panicum turgidum (cereals and pulses)
Parkia biglobosa (spices and condiments)
  Mimosa biglobosa
  Parkia africana
  Parkia clappertoniana
Parkia filicoidea (timbers)

Cassia goratensis
Cassia singueana
Senna sophera (medicinal plants)
Cassia sophera
Senna surattensis (ornamentals)
Cassia surattensis
Sesamothamnus busseanus (medicinal plants)
Sesamum indicum (vegetable oils)
Sesamum orientale
Sesbania grandiflora (ornamentals)
Sesbania sesban (auxiliary plants)
Sesbania aegyptiaca
Setaria palmifolia (forages)
Sida alba (fibres)
Sinarundinaria alpina (timbers)
Arundinaria alpina
Smilax anceps (medicinal plants)
Smilax kraussiana
Solanecio angulatus (medicinal plants)
Crassocephalum bojeri
Senecio bojeri
Solanecio gabonicus
Solanum incanum (medicinal plants)
Solanum bojeri
Solanum mammosum (ornamentals)
Solanum nigrum (medicinal plants)
Solanum tuberosum (carbohydrates)
Sparganophorus sparganophora (medicinal plants)
Sparganophorus vaillantii
Struchium sparganophora
Sphenostylis marginata (carbohydrates)
Sphenostylis erecta
Sphenostylis schweinfurthii (carbohydrates)
Spondias cytherea (fruits)
Spondias dulcis
Stachytarpheta jamaicensis (auxiliary plants)
Sterculia appendiculata (timbers)
Sterculia tragacantha (essential oils and exudates)
Strophanthus mirabilis (carbohydrates)
Strophanthus preussii (medicinal plants)
Strychnos spinosa (fruits)
Stylochaeton lancifolius (carbohydrates)
Symphytum officinale (medicinal plants)
Synaptolepis alternifolia (medicinal plants)
Synedrella nodiflora (medicinal plants)
Tacazzea apiculata (essential oils and exudates)
Tacca leontopetaloides (carbohydrates)
Tacca involucrata
Tacca pinnatifida
Tacca umbrarum
Tamarindus indica (fruits)
Taraxacum officinale (medicinal plants)
Telfairia pedata (vegetable oils)
Ampelosycios scandens
Tephrosia purpurea (auxiliary plants)
Teramnus labialis (auxiliary plants)
Terminalia macroptera (timbers)
Tetracarpidium conophorum (fruits)
Plukenetia conophora
Tetracera alnifolia (medicinal plants)
Tetracera podotricha
Themeda villosa (ornamentals)
Thespesia populnea (timbers)
Thunbergia alata (ornamentals)
Thunbergia grandiflora (ornamentals)
Tournefortia argentea (medicinal plants)
Argusia argentea
Treculia africana (fruits)
Treculia madagascarica
Treculia mollis
Treculia perrieri
Trema orientalis (auxiliary plants)
Trema guineensis
Tribulus cistoides (medicinal plants)
Trichilia tessmannii (timbers)
Trichilia lanata
Trichilia mildbraedii
Trichodesma zeylanicum (medicinal plants)
Tricliceras longepedunculatum (medicinal plants)
Wormskioldia longepedunculata
Trigonella foenum-graecum (spices and condiments)
Trilepisium madagascariense (fruits)
Bosqueia angolensis
Bosqueia boiviniana
Bosqueia phoberos
Triumfetta cordifolia (fibres)
Triumfetta rhomboidea (fibres)
Tropaeolum majus (ornamentals)
Tylophora glauca (medicinal plants)
Tylosema fassoglensis (cereals and pulses)
Bauhinia fassoglensis
Typha angustifolia (fibres)
Typha domingensis (fibres)
Typha australis
Typha elephantina (fibres)
Typhonium trilobatum (carbohydrates)
Typhonodorum lindleyanum (carbohydrates)
Typhonodorum madagascariense
Urena lobata (fibres)
Vallisneria spiralis (ornamentals)
Vallisneria aethiopica
Vernonia cinerea (medicinal plants)
Vernonia colorata (medicinal plants)
Vernonia galamensis (vegetable oils)
Vernonia pauciflora
Vernonia myriantha (medicinal plants)
Vernonia ampla

Vernonia podocoma
Vernonia stipulacea
Vernonia subuligera
Vernonia nigritiana (medicinal plants)
Vernonia pumila (medicinal plants)
Vernonia thomsoniana (medicinal plants)
Vernonia pobeguinii
Vigna adenantha (cereals and pulses)
Phaseolus adenanthus
Vigna angivensis (carbohydrates)
Vigna gracilis (forages)
Vigna multiflora
Vigna marina (forages)
Vigna oblonga
Vigna radiata (cereals and pulses)
Phaseolus aureus
Phaseolus radiatus
Vigna reticulata (forages)
Vigna umbellata (cereals and pulses)
Phaseolus calcaratus
Viola abyssinica (medicinal plants)
Vitellaria paradoxa (vegetable oils)
Butyrospermum niloticum
Butyrospermum paradoxum
Butyrospermum parkii
Vitex doniana (timbers)
Vitex cienkowskii
Vitex cuneata
Warburgia ugandensis (fuel plants)
Withania somnifera (medicinal plants)
Xanthosoma sagittifolium (carbohydrates)
Xanthosoma mafaffa
Xanthosoma violaceum
Zaleya pentandra (forages)
Trianthema pentandra
Zanthoxylum chalybeum (medicinal plants)
Zea mays (cereals and pulses)
Zornia latifolia (forages)

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Index of scientific plant names

Page numbers printed in bold refer to main treatment; page numbers in italics refer to line drawings

Index of vernacular plant names

PROTA in short

The Plant Resources of Tropical Africa (PROTA) programme was initiated in 2000 and developed into an international partnership of 11 institutions in 11 countries during the Preparatory Phase 2000–2003. Since 19 February 2003, PROTA operates as an international foundation domiciled in Wageningen, Netherlands.

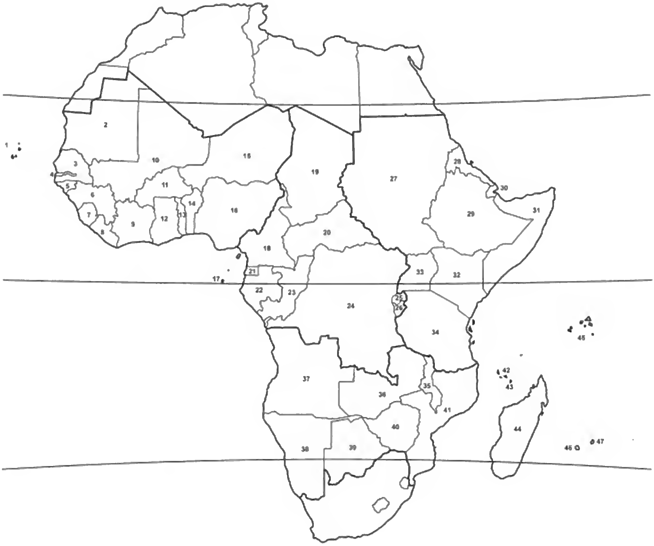
PROTA is a major 'information brokerage and knowledge repatriation' programme. The objectives are to bring the 'world literature' on the useful plants of Tropical Africa, now accessible only to the resourceful happy few, into the (African) public domain, and contribute to greater awareness and sustained use of the plants, with due respect for traditional knowledge and intellectual property rights. PROTA will describe the estimated 7,000 useful plants during the Implementation Phase 2003-2012. The information carriers will be freely accessible Web databases (www.prota.org), a low-price Handbook and CD-Rom series featuring 16 Commodity groups, and Special Products per commodity group for rural development, education, research and policy actors (all in English and French).

PROTA 1: Cereals and pulses	PROTA 9: Auxiliary plants
PROTA 2: Vegetables (2004)	PROTA 10: Fuel plants
PROTA 3: Dyes and tannins	PROTA 11: Medicinal plants
PROTA 4: Ornamentals	PROTA 12: Spices and condiments
PROTA 5: Forages	PROTA 13: Essential oils and exudates
PROTA 6: Fruits	PROTA 14: Vegetable oils
PROTA 7: Timbers	PROTA 15: Stimulants
PROTA 8: Carbohydrates	PROTA 16: Fibres

CTA in short

The Technical Centre for Agricultural and Rural Cooperation (CTA) was established in 1983 under the Lomé Convention between the ACP (African, Caribbean and Pacific) Group of States and the European Union Member States. Since 2000, it has operated within the framework of the ACP-EC Cotonou Agreement.

CTA's tasks are to develop and provide services that improve access to information for agricultural and rural development, and to strengthen the capacity of ACP countries to produce, acquire, exchange and utilise information in this area. CTA's programmes are designed to: provide a wide range of information products and services and enhance awareness of relevant information sources; promote the integrated use of appropriate communication channels and intensify contacts and information exchange (particularly intra-ACP); and develop ACP capacity to generate and manage agricultural information and to formulate ICM strategies, including those relevant to science and technology. CTA's work incorporates new developments in methodologies and cross-cutting issues such as gender and social capital. (CTA, P.O.Box 380, 6700 AJ Wageningen, Netherlands).



WEST AFRICA

1. Cape Verde
2. Mauritania
3. Senegal
4. Gambia
5. Guinea Bissau
6. Guinea
7. Sierra Leone
8. Liberia
9. Côte d'Ivoire
10. Mali
11. Burkina Faso
12. Ghana
13. Togo
14. Benin
15. Niger
16. Nigeria

CENTRAL AFRICA

17. São Tomé et Principe
18. Cameroon
19. Chad
20. Central African Republic
21. Equatorial Guinea
22. Gabon
23. Congo
24. Democratic Republic of Congo
25. Rwanda
26. Burundi

EAST AFRICA

27. Sudan
28. Eritrea
29. Ethiopia
30. Djibouti
31. Somalia
32. Kenya
33. Uganda
34. Tanzania

SOUTHERN AFRICA

35. Malawi
36. Zambia
37. Angola
38. Namibia
39. Botswana
40. Zimbabwe
41. Mozambique

INDIAN OCEAN ISLANDS

42. Comoros
43. Mayotte (Fr)
44. Madagascar
45. Seychelles
46. Réunion (Fr)
47. Mauritius

PROTA, short for 'Plant Resources of Tropical Africa', is an international programme focused on the 7,000 useful plants of Tropical Africa. Its purpose is to make available the wealth of dispersed knowledge on these plant resources for education, extension, research and industry through Internet databases, books, CD-Roms, and derived products such as brochures, leaflets, and manuals. A thorough knowledge of the plant resources is essential for arriving at ecologically balanced and sustainable land-use systems. A large international team of experts is contributing the texts on particular species. All species are described according to a standard format with details on uses, trade, properties, botany, ecology, agronomy or sylviculture, genetic resources, breeding, prospects and literature. In the printed series the species are grouped into commodity groups. More information on www.prota.org.

Vegetables

PROTA 2 deals with the vegetables of Tropical Africa. PROTA's database 'SPECIESLIST' presents about 880 species used as such, but only 350 are 'primary use' vegetables qualifying for treatment in this volume, the other 530 species have been listed as 'Vegetables with other primary use' and referred to other Handbook volumes.
The 350 'primary use' vegetables are described in 275 review articles, implying that about 75 species have no separate article due to lack of information; they are only mentioned in the articles of related species.

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